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ERRATA.

Page 4, line 11 from bottom, for 'zinc,' read 'wire.'
P. 20, " 15 " top, for 'acid in chlorine,' read 'acid and chlorine.'
P. 63, " 2 " top, for 'Wutz,' read 'Wurtz.'
P. 218, " 6 " bottom, for '1227·75,' read '1227·45,' and erase first half of next line.
P. 286, " 22 " top, for '2·97,' read '2·957.'
P. 286, " 17 " bottom, for 'soda,' read 'potash.'
P. 407, " 13 " top, for "Pseudomorphism," read "Isomorphism."
P. 419, bottom line, for 'soda, or the,' read 'soda, and the.'

Vol. VIII, page 379, line 15 from top, for 'Chester Co.,' read 'Delaware Co.'
" p. 383, in table, analysis 2, for 'Emerylite, Pennsylvania,' read 'Margarite.'
" " " " 3, " 'Margarite,' read 'Emerylite.'
" " " second part, for the numbers of the analyses, 1, 2, 3, 4, 5, substitute, 1, 3, 4, 5, 2.
" p. 387, in formula of Kyanite, for '$\bar{\text{A}}\text{l}^2\ \bar{\bar{\text{S}}}\text{i}^3$,' read '$\bar{\text{A}}\text{l}^3\ \bar{\bar{\text{S}}}\text{i}^2$.'
" p. 387, line 23 from top, for '775·5,' read '·7755.'

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. I.—*Experiments on the Electricity of a Plate of Zinc buried in the Earth;* by Elias Loomis, Professor of Mathematics and Natural Philosophy in the University of the City of New York.

In October, 1842, Mr. Alexander Bain discovered that a plate of zinc buried in the earth and connected by a wire with a copper plate similarly buried at the distance of a mile, produced an electric current with which various electro-magnetic experiments were successfully performed. I have lately performed a series of similar experiments for the purpose of ascertaining the circumstances which determine the intensity of the current, and of discovering to what extent this intensity might be increased.

Experiment 1. On the 15th of May, 1849, I took a plate of sheet zinc twelve inches by sixteen, and having soldered to it a copper wire sixty feet in length, buried it two feet beneath the surface of the earth on the north side of the Philosophical Hall of the College of New Jersey. A plate of sheet copper nine inches square, which I shall call copper plate No. 1, was buried in a similar manner twenty-seven feet from the former. The wires from these plates being together one hundred and fourteen feet in length, extended to the upper story of the hall, and were connected with a small galvanometer, made by E. M. Clark of London. The needle (which was two and three-eighths inches in length) was deflected with great violence and finally settled at 66°. The positive current of electricity flowed through the earth from the zinc to the copper plate, and thence through the air back to the zinc plate.

Exp. 2. I substituted for the galvanometer one of Morse's receiving magnets. When the circuit was completed by depressing the key in the usual mode of telegraphing, the armature of the magnet was readily attracted; and after adding a single cup of Grove's battery for the local circuit, the register worked promptly and efficiently. In other words, Morse's telegraph was worked in a beautiful manner, with only the electricity of a small plate of zinc buried in the earth for the main circuit. The preceding circuit, being one hundred and fourteen feet in length, will hereafter be referred to by the name of the *short circuit.*

Exp. 3. I took a longer wire and attached to its extremity a piece of sheet copper four inches by eight, which I call copper plate No. 2. This was dropped into a cistern of water one hundred and twenty-five feet from the zinc plate. Upon connecting the wire with that of the zinc plate, the total length of wire in the circuit being now two hundred and twenty feet, the needle of the galvanometer was instantly deflected 100°, and settled permanently at 50°. The same current was sufficient to work the telegraph apparently as well as before.

Exp. 4. I detached copper plate No. 2 from the wire and simply dropped the end of the wire into the cistern. The needle of the galvanometer was deflected about 30° and settled permanently at 12°. The direction of the current was the same as in all the former experiments. In this case the wire could not well be supposed to serve any other purpose than that of a conductor to complete the electric circuit. In other words the galvanic battery was entire without the copper plate; the battery consisting of the zinc plate and the moisture contained in the earth.

Upon introducing the telegraph register into this circuit, the armature of the receiving magnet was attracted sensibly though feebly. After careful adjustment, the register worked with promptness and certainty.

Exp 5. I again attached copper plate No. 2 to the end of the wire, and increased the length of wire in the circuit to five hundred feet. The galvanometer needle was powerfully deflected and finally settled at 45°. The telegraph register operated beautifully.

Exp. 6. I took up the wire attached to the copper plate and dropped the plate into another cistern four hundred and seventy-five feet from the zinc plate. The length of wire in the circuit was now five hundred and seventy feet. Upon interposing the galvanometer, the needle settled at 36°. The telegraph register operated with ease and certainty.

Exp. 7. I now added two hundred and fifty feet more of wire, making the entire length of wire in the circuit eight hundred and twenty feet; that is, the total length of circuit, including the earth, was now one thousand two hundred and ninety-five feet.

This is designated in the following experiments by the name of the *long circuit.* The galvanometer settled at 34°. The operation of the telegraph was not sensibly impaired.

Exp. 8. I took a wire sixty feet in length, and attached to it a plate of copper in form of a circle eleven inches in diameter, which I shall call copper plate No. 3. I threw this plate into a well near the last cistern, and attached the end of the wire to the former circuit. The galvanometer needle settled at 64°. Upon the short circuit, Exp. No. 2, the galvanometer stood at 70°.

I now inferred that the cisterns used in Experiments 3–7 did not communicate freely with the earth. They were both brick cisterns lined with hydraulic cement. In order to decide the question, the following experiment was tried.

Exp. 9. I adjusted my wire so that the same plate might be thrown alternately into the cistern and well. When the wire terminated with plate No. 3 in the cistern, the galvanometer settled at 52°. When the wire with the same plate terminated in the well, the galvanometer settled at 63°. Thus my suspicion was confirmed, and the cisterns were discarded throughout the remainder of the experiments.

Exp. 10. I attached both plates, Nos. 2 and 3, making together not quite a square foot of surface, to the same wire, and threw them into the well. The galvanometer settled at 66°. Upon the short circuit, Exp. No. 2, the galvanometer settled at 69°.

Exp. 11. I moistened a strip of paper with a solution of iodid of potassium and starch. Upon introducing this into the short circuit the iodine immediately made its appearance upon the positive pole. Morse's telegraphic characters were promptly stained upon the paper, so as to admit of telegraphing with tolerable rapidity. Upon the long circuit, Exp. No. 7, the same effects were produced but not as promptly.

Exp. 12. I moistened a strip of paper with a solution of prussiate of potash in nitro-muriatic acid. This was readily stained a deep blue when the current was transmitted through a steel point. Morse's telegraphic characters were marked upon the paper with promptness.

In experiment No. 4, it was found that the telegraph register could be worked with a current which deflected the needle of the galvanometer only 12°. From a comparison of Experiment 10 with those of Prof. Morse, published in the American Journal of Science, vol. xlv, p. 391, it is inferred that the current generated by the zinc plate when both copper plates, Nos. 2 and 3, were attached to the wire, would have this degree of intensity when the length of the interposed wire was increased to ten miles. In other words, a zinc plate a foot square buried in the earth, with a copper plate of the same size dropped into a well of water, constitute a battery powerful enough to work Morse's telegraph through a distance of ten miles.

This then constitutes a most convenient and economical battery. The first expense of the plates, without the connecting wire is about two shillings. The battery requires no attention from day to day—involves no expenditure for acids—is permanent in its action—and appears to possess every desirable quality for a telegraph for short distances.

In none of the preceding experiments was the wire which formed the circuit wound into a coil, but was stretched out into a long line.

Exp. 13. On the 1st of June, 1849, the galvanometer on the long circuit, Exp. 7, settled at 61°; on the short circuit, Exp. No. 2, it settled at 66°. This is the same as was observed May 15th, the day on which the zinc plate was first buried; although in one instance after a rainy day, an observation of 70° had been recorded. The current during these seventeen days had been remarkably uniform.

I now buried a second zinc plate twenty inches square by the side of the former one, at the depth of two feet beneath the surface of the earth, and connected the two plates by a short wire. The galvanometer on the long circuit settled at 66½°; on the short circuit it settled at 72°. Thus it appeared that by the addition of the second zinc plate which was considerably larger than the first, the strength of the electric current had been increased about one-third.

The following experiments were performed to determine the influence of the size of the copper plate upon the intensity of the current.

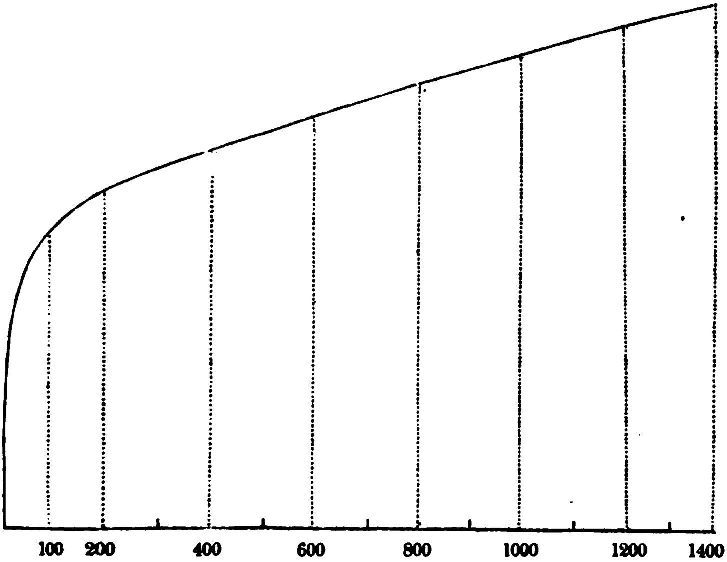
Exps. 14 to 29. I detached copper plates Nos. 2 and 3 from the long wire, and substituted for them a single copper plate forty-eight inches by fourteen immersed in the well. The galvanometer stood at 74¾°.

I now divided the copper plate in the middle leaving a plate twenty-four inches by fourteen immersed in the well. The galvanometer stood at 71½°.

I thus proceeded to divide the copper plate until I had reduced it to three inches by a half inch; after which the plate was entirely removed. I then withdrew the zinc gradually from the well until only three inches of it remained immersed in the water, and noticed at each step the effect upon the needle. The copper wire was $\frac{1}{31}$ of an inch in diameter, and while the copper plate was attached, it was immersed five and a half feet in the water. In the following table, column second shows the dimensions of the copper plate employed; column third shows the entire surface of copper immersed, including both sides of the plate and also the immersed wire; column fourth shows the observed deviation of the galvanometer needle; and column fifth shows the natural tangent of the angle of deviation.

No. of Experiment.	Size of the Copper Plate.	Copper surface immersed.	Deviation of Galvanometer.	Tangent of deviation
14	48 inches by 14	1354 square inches.	74¾°	3·668
15	24 " 14	682 "	71½	2·989
16	12 " 14	346 "	68¼	2·507
17	6 " 14	178 "	66½	2·300
18	6 " 7	94 "	64¾	2·120
19	3 " 7	52 "	62½	1·921
20	3 " 3½	31 "	60¾	1·786
21	3 " 2	22 "	59	1·664
22	3 " 1	16 "	57	1·540
23	3 " ½	13 "	56½	1·511
	Length of wire immersed			
24	6 feet.	10·8 "	56	1·483
25	5½ "	9·9 "	55¼	1·442
26	3 "	5·4 "	46¾	1·063
27	1 "	1·8 "	32¾	·643
28	6 inches.	0·9 "	19	·344
29	3 "	0·45 "	11	·194

The law which these numbers follow is exhibited by the following curve, in which the abscissas represent the amount of copper surface immersed in the water, and the ordinates represent the intensity of the electric current, assuming the intensity to be proportioned to the tangent of the angle of deviation of the galvanometer.



The numbers below the horizontal line represent the square inches of copper surface immersed: the dotted vertical lines represent the corresponding intensity of the electric current.

Thus it appears that for plates less than one square inch, the intensity of the current as measured by its effect upon a magnetic needle, is nearly proportioned to the surface of the plates; but in order to double the intensity of the current yielded by a copper plate of three and one-third square inches, counting both sides, the surface of the plate must be increased fourteen fold; and in order to increase the current fourfold, the surface of the plate must be increased four hundred and twenty fold. In order to double the current again would probably require a copper plate more than sixteen feet square.

The following experiments were performed to determine how far the intensity of the current could be increased by multiplying the number of galvanic elements.

Exp. 30. I buried a plate of zinc six inches square in the earth at a distance of twelve feet from the well used in the preceding experiments. The depth to the surface of the water in the well was also twelve feet. A plate of copper six inches square being attached to a wire and dropped into the well, the galvanometer settled at 45°.

Exp. 31. I then buried a second copper plate of the same dimensions in the earth at a distance of one inch from the first zinc plate, and connected it by a wire with a second zinc plate which was immersed in the well by the side of the copper plate and separated from it to the distance of half an inch by interposed cork. The galvanometer settled at 58°. The tangents of 45° and 58° are in the ratio of ten to sixteen. In this ratio the intensity of the current had been increased by the addition of a second pair of plates.

Exp. 32. I removed the second copper plate to the distance of five inches from the zinc plate which was buried in the earth. The galvanometer settled at 50°. I then interposed between the copper and zinc a third pair of plates of the same dimensions, when the galvanometer settled at 58°. This experiment did not afford much encouragement for increasing the number of plates beyond two pairs of elements.

Exp. 33. I repeated the last three experiments in a new position about four feet from the former one. In this second locality the soil was only eight inches deep, a flat stone lying underneath. With one zinc plate in the earth and one copper plate in the well the galvanometer settled at 26°.

Exp. 34. With a copper plate in the earth distant one inch from the zinc, and a pair of plates in the well, as in experiment 31, the galvanometer settled at 44°. The tangents of 26° and 44° are almost exactly in the ratio of one to two. The intensity of the current was therefore doubled by the addition of a second pair of plates.

Exp. 35. I removed the second copper plate to the distance of twelve inches from the zinc which was buried in the earth. The galvanometer settled at 28½°. I placed the copper plate six inches from the zinc, when the galvanometer settled at 30°. I placed the copper plate five inches from the zinc when the galvanometer settled at 33°. I then interposed a third pair of plates when the galvanometer settled at 40½°. In this experiment the three pairs of plates did not furnish the same intensity as two pairs in Exp. 34. By bringing the plates a little closer together some increase of effect would have been obtained; but although the experiment was several times repeated, nearly the same advantage appeared to be lost in every instance by the separation of the second copper plate from the first zinc, as was gained by the interposition of the third pair of plates.

Exp. 36. I took three pairs of plates six inches by seven, all well secured at distances of one-third of an inch from each other. The outer copper plate was connected by a wire with the zinc plate buried in the earth, as in Exp. 30. The outer zinc plate was connected with the copper plate buried one inch from the zinc, as in Exp. 31. Upon lowering the battery into the well the galvanometer stood at 62°.

Exp. 37. I removed one pair of plates from the battery, the interval between the remaining ones being still one-third of an inch, when the galvanometer stood at 60¾°.

Exp. 38. I removed a second pair of plates from the battery, leaving only one pair separated by a distance of one-third of an inch in the well; and one pair separated by an inch buried in the earth, when the galvanometer stood at 70°.

Thus it appears that one pair of plates immersed in the water affords a stronger current than two or three pairs. The difference between two and three pairs is altogether trifling.

Exp. 39. I removed the copper plate from the ground and the zinc plate from the well, when the galvanometer settled at 53°. The tangents of 53° and 70° are almost exactly as one to two. This experiment therefore leads to the same conclusion as Exp. 34, that with one pair of elements buried in the earth and one immersed in the well, the intensity of the current is double of that furnished by a single pair.

Exp. 40–54. The following experiments were made to determine the influence of the size of the zinc plate upon the intensity of the current. I buried a plate of sheet zinc twelve inches square on the spot employed in Exp. 30. A plate of copper twelve inches by fourteen was attached to a wire and immersed in the well. Upon connecting the two plates by a wire the galvanometer stood at 65½°. I then removed one-half of the zinc plate when the galvanometer stood at 64½°. I continued thus to divide the zinc plate and record the indications of the needle until the plate was reduced to as small dimensions as could well be used. The following table contains the observations. Column second shows the dimensions of the zinc plate employed; column third shows the entire surface of zinc buried in the earth, counting both sides of the plate; column fourth shows the observed deviation of the galvanometer needle; and column fifth shews the natural tangent of the angle of deviation.

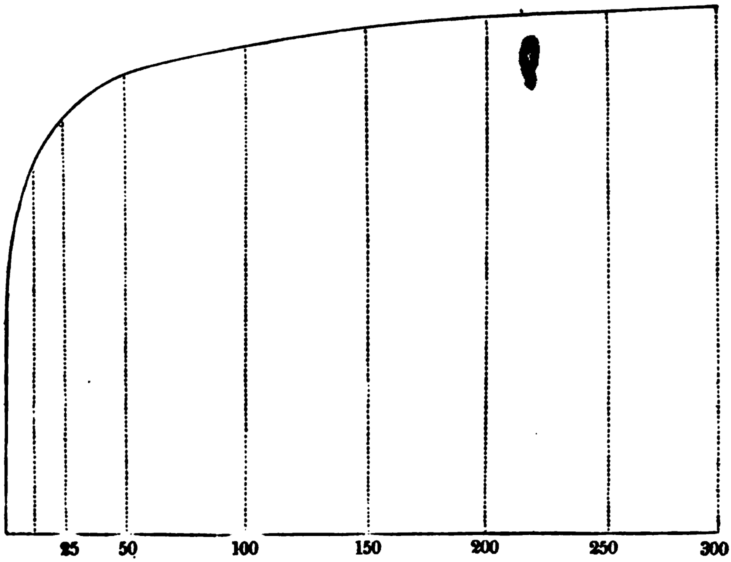
No. of Experiment.	Size of the Zinc Plate.			Zinc surface buried.		Deviation of Galvanometer.	Tangent of deviation.
40	12	inches by	12	288	square inches.	65½°	2·194
41	12	"	6	144	"	64½	2·097
42	6	"	6	72	"	63¼	1·984
43	6	"	3	36	"	61¾	1·861
44	3	"	3	18	"	58¾	1·648
45	3	"	2	12	"	57	1·540
46	3	"	1	6	"	53½	1·351
47	2	"	1	4	"	52¼	1·292
48	1	"	1	2	"	49½	1·171
49	1	"	½	1	"	45	1·000
50	1	"	¼	½	"	42½	0·916
51	½	"	¼	¼	"	37½	0·767
52	¼	"	¼	⅛	"	31½	0·613
53	¼	"	⅛	$\frac{1}{16}$	"	26¾	0·504
54	⅛	"	⅛	$\frac{1}{32}$	"	24	0·445

Exp. 55. In several of the last experiments the solder with which the copper wire was attached to the zinc plate covered a considerable portion of the zinc surface and impaired the effect of the plate. I therefore cut a strip one-tenth of an inch wide from thin sheet zinc and soldered it to the end of a copper wire. When this was inserted two inches in the ground and connected with the copper plate in the well, the galvanometer settled at 46¼°.

Exp. 56. When the same zinc wire was inserted half an inch in the ground, the galvanometer settled at 36¼°.

Exp. 57. When the end of the zinc barely pressed upon the ground by its own weight, the galvanometer settled at 17½°.

The law which the preceding numbers follow is exhibited by the following curve line, in which the abscissas represent the



The numbers below the horizontal line represent the square inches of zinc surface buried in the earth: the dotted vertical lines represent the corresponding intensity of the electric current.

amount of zinc surface buried in the earth, and the ordinates represent the intensity of the electric current, assuming the intensity to be proportioned to the tangent of the angle of deviation of the galvanometer.

From these experiments it appears that a small wire of zinc inserted half an inch in the ground affords a current half as strong as a plate an inch square; and a plate one inch square affords a current more than half as strong as a plate one foot square; so that even less advantage is gained by increasing the surface of the zinc plate than the surface of the copper plate.

Exp. 58. I took a strip of sheet zinc one-tenth of an inch wide and twenty inches long, and having soldered to it a copper wire sixty feet long, inserted it vertically in the ground near the Philosophical Hall. Upon dropping the end of the copper wire, Exp. 7, seven hundred and sixty feet in length, into the well without any plate attached, the needle settled at 38¾°. This current worked the telegraph with promptness and efficiency.

The following experiments, No. 59 to 65, were tried with the electricity of the common machine.

Exp. 59. A Leyden jar having a capacity of one quart was charged with the electricity of a common machine, and the charge passed through the long circuit used in Exp. 7. The jar rested upon a table with a wire attached to the zinc plate underneath it. Upon bringing the wire attached to the copper plate near to the knob of the jar the charge passed apparently without difficulty.

Exp. 60. I applied my left hand to the outside of the jar which rested upon the zinc wire as before. On bringing the other wire which I held in my right hand near the knob, the jar was discharged and I received a severe shock.

Exp. 61. The same experiment was repeated with the short circuit No. 2. I again received a shock, but much feebler than before.

It appeared that the circuit through which the jar was discharged in the last two experiments, offered so much resistance to the passage of the fluid, that at least a portion of the charge preferred the shorter route through my body. In order to determine whether this resistance arose from the wire or the interposed earth, the following experiments were tried.

Exp. 62. I took a copper wire $\frac{1}{21}$ of an inch in diameter and one hundred and twenty feet long, and arranged it round the Philosophical Hall so that I could discharge a jar through the entire length or any portion of it at pleasure. When I discharged the jar through thirty feet of wire, I perceived not the slightest shock, although I held one end of the wire in my right hand, and with my left hand clasped the outside of the jar.

Exp. 63. When forty feet of wire were introduced, the shock would not probably have been noticed, if it had not been a particular object of attention. With sixty feet of wire the shock was so slight that it might have escaped notice under ordinary circumstances, but when I clasped the wire very firmly in my hand, the shock was quite decided. With one hundred and twenty feet of wire the shock was felt in both my wrists and slightly up to my elbows.

Exp. 64. In order to obtain some measure of the amount of resistance which this current was capable of overcoming, I took two cat-skins prepared for electric experiments with their fur upon them. One of them was lined with cotton cloth, cotton batting and silk. I doubled each of the skins and laid them together so as to make four layers of fur, the whole being nearly an inch thick when well compressed. When I discharged the jar through the short circuit, as in Exp. 61, my right hand being protected by four thicknesses of fur, I perceived no shock.

Exp. 65. When the jar was discharged through one hundred and twenty feet of wire as in Exp. 63, my hand being protected by four thicknesses of fur, I received a sensible shock. With six thicknesses of fur I perceived no shock, except when some part of my hand or wrist was allowed to come within an inch of the unprotected wire, in which case I received a severe shock, although I held eight or more thicknesses of fur in my hand.

Similar experiments were tried with from one to two hundred folds of silk and with similar results.

The length of wire employed in Exp. 65 was but slightly greater than the wire employed in Exp. 64; and was considerably less than the entire circuit employed in that experiment including the earth. Hence we must conclude that the twenty-seven feet of earth included in the circuit of Exp. 64, offered no appreciable resistance to the passage of the electric fluid. It is inferred, therefore, that the resistance detected in Exps. 60 and 61, was due mainly if not entirely to the length of wire in the circuit.

It is remarkable that the electricity of a single zinc plate should traverse this long circuit so freely, while the electricity of a charged jar seeks in preference the circuit through the human body, although protected by a considerable thickness of the poorest conductors known.

The following experiments were made to determine the influence of the length of the conducting wire upon the intensity of the current.

Exp. 66. I attached a copper plate fourteen inches by twenty-four to the end of the wire which was immersed in the well. I then added six hundred and thirty feet more of wire, making the length of wire in the circuit fourteen hundred and fifty feet, so that the entire circuit, including the four hundred and seventy-five feet of earth, was one thousand nine hundred and twenty-five feet. The galvanometer settled at 69¼°.

Exp. 67. I united the zinc wire, Exp. No. 58, instead of the zinc plates, to the long copper wire, making the length of circuit the same as in the last experiment; when the galvanometer settled at 47¼°.

Exp. 68. I detached five hundred and ten feet of wire, leaving the length of wire in the circuit nine hundred and forty feet. When this was connected with the zinc plates, the galvanometer settled at 69½°.

Exp. 69. I detached three hundred and seventy more feet of wire, leaving the length of wire in the circuit five hundred and seventy feet; when the galvanometer settled at 70°.

Thus it appears that when the length of the circuit was doubled, the intensity of the current was but slightly impaired, which favors the conclusion that the current thus generated might be employed for telegraphing to considerable distances. Mr. Vail succeeded in telegraphing from Washington to Baltimore with such a battery. The size of the plates employed in his experiment was five feet by two and a half.

Exp. 70. I substituted the zinc wire for the zinc plates on the same circuit as in Exp. 69, when the galvanometer settled at 48¼°.

Exp. 71. I connected the zinc plates with copper plate No. 1, on the short circuit, Exp. No. 2, when the galvanometer settled at 72¼°.

Exp. 72. I substituted the zinc wire for the zinc plates on the same circuit, when the galvanometer settled at 48½°.

The preceding experiments were all completed by the 25th of June, and no further experiments were made until September.

Exp. 73. On the 11th of September, I repeated Exp. No. 71, when the galvanometer settled at 71½°.

Exp. 74. On the 3d of October, I repeated the last experiment, when the galvanometer settled at 75°.

Thus for nearly five months, a plate of zinc buried in the earth furnished a current of electricity of an intensity well nigh constant. The entire range of the galvanometer needle was only four degrees. These variations were ascribed to changes in the moisture of the earth, as the intensity of the current was generally observed to increase after a long rain. It does not appear however that on the whole the intensity has diminished during these five months, and it is remarkable that the last observation was the highest made during the entire period, but the ground was at this time unusually wet in consequence of a recent rain.

ART. II.—*Geology of Canada.*

From the Proceedings of the Association for the Advancement of Science, at Cambridge, August, 1849.

MR. T. S. HUNT, of the Geological Commission of Canada, made an oral communication upon the results of the geological exploration of that country, and showed by the aid of a map, the general distribution of the formations and their relation to the rocks of New England. The following is a summary of his remarks.

In presenting the report made by W. E. LOGAN, Esq. to the Provincial government, embracing the results of the survey of 1847–8, I beg leave to offer a brief sketch of the results which have been developed by himself and his assistants. The feature which first claims our attention in looking at the geological structure of this country, is a formation of syenitic gneiss, often passing into mica schist, and interstratified with crystalline limestone, which forms a ridge of high land extending from the coast of Labrador along the north side of the St. Lawrence, at a distance of from twelve to twenty miles from the shore, until it crosses the Ottawa, near Bytown, whence it is traced across lake Simcoe to the shores of Lake Huron, where its northern limit is observed near the mouth of the French river, while it again appears at the southeastern extremity upon Matchedash Bay. Resting upon this are a series of rocks forming the whole north coast of the lake and numerous small islands. It is made up of sandstones, often coarse-grained, and sometimes becoming conglomerate from the presence of red jasper pebbles. These beds are associated with slates, and one or more bands of limestone. The slates are greenish, and highly chloritic, often containing epidote; sometimes they assume the character of conglomerates, from the presence of pebbles of syenite. The formation is much cut by greenstone dykes, and exhibits very frequently interstratified beds of greenstone often of great thickness. Both these and the sedimentary beds contain metalliferous quartz veins, of which the copper mines of this region are examples. Resting unconformably upon the tilted edges of this formation, and in other places directly upon the southern limit of the syenitic gneiss, appear the silurian rocks, identical with those which are found in New York, and cover the peninsula between Lake Huron and Lake Ontario. Beginning with the rock designated in the New York nomenclature the Potsdam sandstone, we have upon the Manatoulin Islands and the coast between the Matchedash Bay and Sarnia, a complete exposure of those formations known as the Trenton limestone, Utica slates, Loraine Shales, Medina sandstones, and the Niagara limestones, with the rocks of the Clinton group. All of these are well characterized by their respective fossils, and are spread out quite undisturbed at a very gentle dip of about thirty-five feet in a mile. The thickness of these rocks, as exhibited in a section across the Grand Manitoulin and La Cloche Islands, was found to be from the base of the Potsdam sandstone to the top of the Niagara limestone, 1,273 feet.

Passing to the east, we find that the syenitic rocks have divided near where they cross the Ottawa, and taking a southward course, are spread over a considerable extent of country between the Ottawa and the St. Lawrence. Crossing this river below Kingston, they constitute the greater part of the Thousand Isles, and are extensively developed in the northern counties of New York.

The country thus bounded on the west and north consists of a broad valley of twelve to twenty miles on the north, and thirty to forty miles on the south side of the St. Lawrence, which at its southwestern extreme, includes the valley of the Richelieu and the northern part of lake Champlain. On the southeastern side of this is a mountain belt of from twenty-five to thirty miles in width; this is the prolongation of the Green Mountains of Vermont, which further north constitute the Shicksbock and Notre Dame mountains of Gaspé. This mountain range, coincident with the course of the river, is bounded at its southeastern base by a valley of gently undulating land, from twenty to thirty miles in width, which may be traced from the upper part of the Connecticut river to the upper portion of the St. Francis; thence by the eastern branch of the Chaudière to the Rivière de Famine, a tributary of the Chaudière, the valley is continued in the course of the St. John's until further on, it falls into the valley of the Ristigouche, and is thence traced quite into the Baie des Chaleurs. The general strike of the rocks is coincident with the direction of the St. Lawrence and the mountain range, and the same geological formations appear continuous without.

If a line be drawn from St. Scholastique, upon the north shore of the Ottawa, passing forty miles S. E. to Montreal, and thence to Canaan, on the Connecticut river, in the north of Vermont, we shall have a section nearly at right angles to the general course of the formations. Commencing at the northwest, the first rock which presents itself resting upon and skirting the bases of the hills of the syenitic gneiss and crystalline limestone, is a fine sandstone, which is seen on both shores of the Ottawa at its mouth, constituting there a considerable island, and is thence traced south into the county of Beauharnois, where it spreads out to a considerable width, and passing into the state of New York, divides against the syenitic formation. Sweeping around its base, one portion passes up the valley of the St. Lawrence, and the other is developed in that of Lake Champlain, where it is recognized as the Potsdam sandstone. To the northeast it probably skirts the base of the syenitic rocks, and has indeed been observed at the Falls of the St. Maurice, but owing to the great depth of tertiary deposit which fills the valley, the opportunities of examining it are but few. The next rock upon the line of section is a limestone, very silicious at the base, but pure and thick-bedded in the middle, gradually becoming bituminous and shaly toward the top. This formation, exposed at a very moderate dip, constitutes the greater portion of the island ot Montreal, and crossing below to the north side of the river, is lost beneath the tertiary sands and clays. To the south, it sweeps around the extremity of a trough, until it reaches St. John, where either turning over an anticlinal or affected by a dislocation, it turns up the west side of the Richelieu and runs into New York.

This formation is shown by its fossils to be referable in its lower part to the calciferous sandstone, while the upper beds are the Trenton limestone. It contains interstratified greenstone trap, sometimes amygdaloidal, which constitutes the mountain of Montreal. Resting upon this limestone is a set of black shales which appear on both shores of the river before Montreal, and constitute some islands in its bed. To the south, these shales, which are the Utica slates, follow the course of the limestone, keeping the east shore of the Richelieu, and spreading out to a considerable breadth, constitute the region of country between the mouth of Lake Champlain and Missisquoi Bay. To these succeed a series of shales, bluish and grayish, arenacious, and more or less calcareous, which are evidently from their fossils the Loraine shales. These are seen upon the Richelieu at Chambly, upon the Yamaska near St. Hyacinthe, and in several other points along the line of strike. They present a considerable breadth, and are not improbably kept at the surface by some little undulations. Succeeding these, after two or three miles, covered by tertiary sands, appears a repetition of the Trenton limestones, which have been traced from Philipsburg, upon the line of Vermont, through the Seigniory of St. Hyacinthe, to Deschaillons, where they cross the St. Lawrence, and are exposed again upon the northern shore. These are followed by a repetition of the Utica slates and Loraine shales, which flank the limestones upon the St. Lawrence, and are exposed at various points along the strike. Upon the Barbue river, in the Seigniory of St. Hyacinthe, occurs what appears to be a small trough of higher rocks, consisting of heavy greenish sandstones, interstratified with red and chocolate-colored slates, sometimes mixed with green bands. These red slates are highly ferruginous, and sometimes contain traces of oxyd of titanium. Near the line of Vermont, appears, succeeding the Trenton limestone, the extremity of a similar trough of slates and sandstones, more or less calcareous, which is prolonged into Vermont. In Yamaska mountain a mass of trap lies in the line of the St. Hyacinthe sandstones and red slates, and brings up on its flanks similar sandstones and bluish and greenish slates, with a crystalline yellow-weathering limestone. The sandstones near the trap contain mica and plumbago.

These rocks, however, are not seen upon the line of section, but in their strike occur the bluish and grayish calcareous and arenaceous shales, which are followed by light greenish and ash-gray slates, interstratified with gray sandstones. Following these appear the red slates with green bands and their accompanying sandstones, which are sometimes finely conglomerate and more or less calcareous, often containing mica and graphite. These are associated with bands of a greenish chloritic limestone, holding small portions of oxyd of chromium in some form, and near the base, with one or two beds of greyish limestones. South of this section line, the strata on each side of this deposit converge, but northwardly the breadth gradually increases, and seems to show that these rocks form a trough more or less disturbed by undulations. Following the western side of the trough, the slates with their accompanying sandstones, crossing the St. Francis, are seen at St. Nicholas on the St. Lawrence, and in the rear of Point Levi near Quebec. On the eastern side, the slates are followed to Roxton, where affected by an undulation, they sweep round towards Shefford Mountain, and thence are traced to Inverness on the Becancour, accompanied by the beds of limestone, already mentioned as associated with them at the base. Beyond these, on the line of section, are a set of gray and black clay slates, with thin-bedded sandstones and limestones, which although presenting no fossils, appear in their general characters identical with those on the other side of the trough and with the fossiliferous beds of the Richelieu and Yamaska. These rocks appear to run upon an anticlinal to Shefford, where an undulation has been described as carrying the sandstones to the east; thence upon another anticlinal across the Nicolet, where the dark slates and limestones are traced around into a narrow anticlinal valley which runs parallel with the other anticlinals, and is continued to the province line in the township of Sutton.

This double trough contains two great masses of trap, which constitute Broome and Shefford mountains, and appear to have disturbed and altered the rocks to a considerable extent. South of these intrusive rocks we have first upon the section, greenish and gray clay slates, followed by a belt of silicious and calcareous rocks, which vary from a somewhat arenaceous limestone to a feebly calcareous sandstone. These are seen in some places divided into three bands by the intervention of clay state, probably by undulations, which produce repetitions.

The limestone is dolomitic, and is cut in all directions by great numbers of quartz veins; it sometimes contains garnets, and is associated with iron and copper pyrites. At the distance of about a mile is another band of limestone precisely similar, and accompanied, like it, with slates and quartzose beds, which seem to be altered sandstones, and make the first high lands of the mountain district. This ridge, with its two bands of dolomite, appears to be synclinal, and it is traced about ten miles from the province line, where it dies out. Here another hill about half a mile to the S. E., apparently an anticlinal, takes up the same measures.

To these succeed a series of more or less quartzose chloritic rocks, with an imperfect slaty cleavage. They seem to be altered sandstones, which upon their western border, where the alteration has been less profound, still present their original structure. Following these, appears a band of limestone resembling the last, and often divided into two or three belts by green chloritic or gray talcose slates, interstratified with beds of an impure specular iron ore, more or less mixed with chlorite and often titaniferous. The limestones sometimes contain green and purplish talc and occasional crystals of chromic iron; they are marked by the same quartz veins as before. About two miles farther on, a precisely similar belt occurs, and the interval is filled with talcose, chloritic and epidotic slates, associated with bands of magnetic and specular iron. The epidote forms little nodules, and is often associated with quartz; rutile with specular iron is sometimes found crystallized in quartz veins. From this, extending to the Sutton valley, which is the supposed prolongation of the anticlinal, is about a mile of hard quartzose rocks slightly chloritic.

Another section is presented upon the St. Francis, which cuts the rocks nearly at right angles; it shows the dark colored slates and limestone supporting greenish silicious slates, followed by a belt of brown-weathering dolomite, interstratified and accompanied with purple sandstones and red slates, to which succeeds at a distance of about a mile, another belt of limestone, with quartzose bands. The intermediate rocks are sandstones, and conglomerates, often almost pure quartz; southeast of the limestone are seen two or three miles of chloritic rocks, with nodules of epidote and quartz, followed by a band of dolomitic limestone, with veins of magnetic and specular iron ore, and associated with talcose slate. To this succeeds an extent of heavy quartz rock, slightly talcose, and another band of dolomite interstratified with talcose slate, which is followed by the same fine greenish silicious slates as were observed on the western side. Beyond these are found the dark slates with their thin limestone beds, which, as has been already remarked, have been traced around to the opposite anticlinal. The fact that the dolomites and sandstones within, are traced around in the same manner, and the similarity in their lithological characters, shows that they are on opposite sides of a synclinal.

On the line of section, about a mile beyond where the Sutton dolomites would cross, occurs another belt of dolomite associated with soapstone and green chromiferous talc. In its strike we find in one place a band of soapstone filled with bitter-spar, and passing on the northwest into a dolomite of the usual character, while on the southeast is a narrow band of green serpentine. Another dolomitic band occurs a little farther, associated with green talc, serpentine and soapstone. It has been followed for a considerable distance, and in one place consists of soapstone with patches of dolomite, which in the distance of about three hundred yards on the strike, passes into a band of dark green serpentine with soapstone. At other places in the strike, the soapstone is associated with chromic iron, and in one place a bed of magnesite with chromiferous talc. These appear to constitute a trough, and the interval is filled with coarse quartzose chloritic slates, occasionally epidotic, with imbedded crystals of magnetic and specular iron; mica and feldspar are not unfrequently met with.

Following this, the rocks for the next five miles are coarse chloritic micaceous schists, often feldspathic, passing into gneiss, and in some places, very quartzose. About three miles on the line of section, is a band containing talc and calcareous spar, the latter making a considerable portion of the rock, which is stained green with oxyd of chrome. East of this the rock is more feldspathic and contains small crystals of tourmaline. These measures as they go south expand into a wide mountain tract, the summit of which, Sutton mountain, is more than four thousand feet above the St. Lawrence. A valley in the line of the chromiferous calcareous rocks divides the mass into two ridges, one of which dies down very soon, while the other crosses the line of section and is lost a few miles farther north; this region still requires further examination, to determine accurately the relations of the western portion.

On the eastern side of this range occurs a belt of soapstone and serpentine, which has been traced at intervals a distance of twenty miles along the west borders of the Missisquoi. On the west it is bounded by a quartzose chloritic band, associated with a translucent silicious rock of a corneous lustre and fracture. In the strike of the serpentine further north, dolomite is found. On the east side of the river, at the distance of a mile and a half from the former, another serpentine band occurs; the interval is filled with slates and gray quartz rock, with some beds of chloritic and epidotic rocks and a curious jaspery quartz rock containing epidote. This band of serpentine has been traced one hundred and thirty-five miles from the province line across the Chaudière, to the township of Cranbourne. In some parts, it seems to pass into or is associated with a diallage rock, and in others to be a mixture of quartz and serpentine. Like the western band, it is accompanied with soapstone and contains veins and disseminated grains of chromic iron.

Beyond this occur clay slates with beds of white, compact quartz of a scaly fracture and horny lustre, containing often imbedded diallage, hornblende, pyroxene or feldspar; sometimes the rock is nearly homogeneous, but at other times grains of angular, transparent quartz show clearly its conglomerate character. This rock accompanies the serpentine throughout, and constitutes a range of mountain peaks, one of which, Orford Mountain, is more than four thousand feet above the sea. Beyond this still, on the line of section is a band of impure dolomite, which farther north in the strike is replaced by soapstone, magnesite, and serpentine; a similar band is seen again after an interval of a mile, filled with gray slate and the corneous rock.

To these rocks follow gray fossiliferous limestones interstratified with calcareous slates, which form apparently two narrow parallel troughs, one on each side of Lake Memphremagog. On the east side, at Georgeville, they are followed by gray and black glossy slates, and then by talcose and chloritic slates, often micaceous and associated with quartzose beds, and others very talcose; in the strike of these upon the lake appears a band of serpentine, followed by fine silicious talcose slates. From the position of these rocks, there appears evidence of a great dislocation which has divided the fossiliferous troughs and brought up the corneous rock in a mountain mass on the west side of the lake. Evidence of an anticlinal in this line is found in the dip of the fossiliferous limestones near the quartzose rocks farther on in the strike. Beyond these rocks, east of Georgeville, highly crystalline limestones appear, which however still display fossils that admit of identification.

The remaining twenty miles of the section to the Connecticut exhibit these crystalline micaceous limestones, interstratified with soft micaceous slates; the calcareous beds predominate for a few miles, but the calcareous matter finally gives place to silicious, and the slates become stronger. Some of the prior argillaceous beds contain chiastolite, and others exhibit hornblende and garnets. The limestones are more or less micaceous, and often very crystalline; some are quite white, while others are grayish or blackish. Even the most crystalline present on their weathered surfaces the forms of encrinal discs and corals; and in several the characteristic *Favosites gothlandica*, with various species of *Cyathophyllum* and *Porites* are observed. At Dudswell in the line of the strike, the fossiliferous beds are finely exposed, and upon the Rivière de Famine, the rock, which is here less crystalline, exhibits, besides these and other fossils, the *Atrypa affinis*. The fossiliferous beds appear to be near the base of the formation. The rocks of this valley, southeast of the corneous range, are often pierced with masses of a fine-grained, beautiful granite, which forms large dykes and often considerable areas, displacing the calcareous formation. A range of granite-topped hills bounds the valley on the southeast, to the sources of the Chaudière, and constitutes the height of land.

The facts which we have stated seem to show that the sandstones and red slates with their chromiferous chloritic bands, are identical with the dolomitic, chloritic and quartzose rocks of Sutton valley, and these with the serpentines and quartzose rocks of the valley of the Missisquoi; so "that the whole of the Green Mountain rocks, including those containing the auriferous quartz veins, belong to the Hudson River group, with the possible addition of a part of the Shawangunk conglomerates." The fossiliferous rocks of the St. Francis valley are evidently Upper Silurian and referable to the Niagara limestones; a similar formation has been met with at Gaspé and traced one hundred and fifty miles S.W.; and from the similarity of the Notre Dame to the Green Mountains and the fact that the Hudson River rocks are continuous along the St. Lawrence to Cape Rosier, we may conclude that the Upper Silurian rocks will be found continuous, or nearly so, throughout. They constitute the calcareo-micaceous formation of Prof. Adams, which he has traced nearly to the southern line of Vermont. Resting upon this formation in Gaspé is a body of arenaceous rocks, seven thousand feet thick, which apparently correspond to the Chemung and Portage group of New York, with the old red sandstones. As this formation is found extending quite to the Mississippi, it is probable that it will accompany the Silurian rocks through New England and surround the coal fields of New Brunswick, of Eastern Massachusetts and Rhode Island. To this may perhaps be referred in part the rocks of the White Mountains, which may sweep around the Western border of the Massachusetts anthracite formation until lost under the super-carboniferous rocks of the Connecticut River. The limestones of Western New England seem to be no other than the metamorphic Trenton limestones of Phillipsburg, while the chlorito-epidotic rocks and serpentines of Sutton valley appear again in the rocks of southern Connecticut between these limestones and the new red sandstone. With such a key to the structure of the metamorphic rocks of New England and of the great Appalachian chain of which these form a part, we may regard the difficulties that have long environed the subject as in a great degree removed, and the bold conjectures as to their metamorphic origin which have been from time to time put forth, fully vindicated.

Art. III.—*Ash Analyses;* by Jno. A. Porter.

[Read before the Cambridge Scientific Association, Sept. 27, 1849.]

The following analyses of the ashes of hay, oats and the refuse of the whiskey distillation from potatoes, were intended as the starting point of an investigation which had for its object the consideration of the proportions and relations of the salts contained in the food, and in the liquid and solid excrements of animals. This investigation was interrupted by circumstances, but as the analyses have a certain value independent of the special object for which they were intended, they are here made public. The method employed was, without material variation, that of Fresenius and Will, (see Fresenius's quantitative analysis). The alkalies were determined by the indirect method, that is, weighed together either as sulphates or as chlorids, and the quantity of each calculated from that of the sulphuric acid in chlorine found in the mass.

	Potato refuse.	Oats.	Hay.
SiO_2	2·84	53·97	30·01
SO_3	6·10	0·49	2·11
PO_5	16·78	17·35	15·43
CO_2	12·27	——	0·68
KO	38·52	12·94	20·80
NaO	4·47	2·02	10·85
CaO	5·19	3·00	8·24
MgO	7·33	7·08	4·01
Fe_2O_3	1·50	0·60	1·83
$NaCl$	4·00	——	5·09
	99·00	97·45	99·05

The hay was from the grass commonly known as bluetop.

Art. IV.—*A Product of the action of Nitric Acid on Woody Fibre;* by Jno. A. Porter.

[Read before the Cambridge Scientific Association, Sept. 27, 1849.]

The occasion of the investigation, the results of which are here given, was the appearance in the Annales de Chimie et de Physique,* of an article by Prof. Sacc of Neufchatel, Switzerland, on the functions of pectic acid in the vegetable kingdom. He supposes that woody fibre is a product of its transformation, and that the retransformation of woody fibre into pectic acid takes place in plants, under certain circumstances. That the latter transformation is possible he conceives himself to have proved, by subjecting woody fibre to the action of nitric acid, the product of such action being a substance which he regards as pectic acid. From this in connection with other circumstances, he infers the probability of the same change under the influence of certain agencies in the living plant. The grounds presented by Prof. Sacc for believing that the substance above mentioned was pectic acid, are scarcely sufficient. The object of the present investigation, undertaken at the suggestion of Prof. Liebig, was to decide this point.

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* Ann. de Chim. et de Phys., [3], xxv, 219–230.

Prof. Sacc's process was repeated, and the reactions of the substance obtained were compared with those of the substance acknowledged as pectic acid, obtained from turnips. The latter was prepared according to the method of Chodnew.*

200 grammes shavings of white pine were heated some hours with 2 kilogrammes nitric acid of commerce and 400 grammes distilled water, and the white pasty mass that resulted washed out with water, likewise distilled. Prof. Sacc found a sample of the mass thus obtained, perfectly soluble in dilute ammonia, and it was this substance dried at 212° F. that he subjected to analysis. The mass obtained by myself was not perfectly soluble in water containing ammonia. A substance of syrupy consistence remained in small quantity upon the filter. The whole quantity was therefore treated with ammonia and the solution filtered and afterwards precipitated by hydrochloric acid. The precipitate was washed out, at first with slightly acidified water, then with pure water and finally with alcohol. After thoroughly drying at 212°, this substance was of a reddish gray color.

A difference in its behavior and that of the pectic acid from turnips is observable on washing out with alcohol—the latter becomes fibrous on being pressed with the hand; the former retains its slimy consistence.

The following are the results of the comparison of the two substances dried at 212°.

The pectic acid is slightly soluble in boiling water and its solution coagulable by sugar or alcohol. The substance from wood is on the contrary insoluble in water.

The pectic acid is easily soluble in alkalies and reprecipitable by acids as a perfectly transparent jelly. The substance from wood is difficult of solution in alkalies, and the precipitate, at first transparent, contracts rapidly to white translucent flocks. From a solution more strongly alkaline it is precipitated as a light white powder; this was not the case with the pectic acid.

The alkaline solutions of both substances are precipitable by alcohol. Either substance boiled with excess of potash loses after a time its property of being precipitated by acids.

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* Annalen der Pharmacie, li, 355.

The behavior of alkaline solutions of both substances toward bases is, as far as observed, similar. The silver, lead and copper salts, for instance, possess a similar appearance.

Either substance treated with hydrochloric acid, imparts a red color to the liquid. Sulphuric acid acts similarly, at the same time blackening the substance and giving off the color of caramel. With moderately dilute nitric acid their action is different. The pectic acid is partially transformed into mucic acid, which separates on cooling as a white crystalline powder, and is further recognizable by its insolubility in alcohol and its difficult solubility in water. This action was observed by Frémy. Chodnew obtained no mucic acid, probably because too concentrated acid was employed. The substance from wood, boiled with acid of the same concentration, is gradually transformed into oxalic acid; the solution yields no precipitate on cooling.

The substance employed in the following analyses was dried at 212°, then pulverized and afterward dried again at 212°, until there was no farther loss of weight. It contained no trace of nitrogen.

Its per-centage of ash was determined in two portions.

I. 0·5390 grm. yielded ash, 0·0020 grm. =00·37 per cent.
II. 0·4768 " " " 0·0018 " =00·38 per cent.
Mean, - - - - - - 00·375 per cent.

Three combustions of the substance were made with chromate of lead. The results were as follows:

I. 0·5583 grm. yielded 0·8847, CO_2 and 0·2925, HO.
II. 0·3531 " " 0·5630, " " 0·1892, "
III. 0·4602 " " 0·7256, " " 0·2383, "

The composition in hundred parts, calculated from these analyses, taking the ash into account, is as follows:

	I.	II.	III.
C	43·38	43·64	43·16
H	5·84	5·97	5·78
O	50·78	50·39	51·06

The formula $C_{16}H_{13}O_{14}$ expresses very accurately this composition:

	Mean of analyses.	Calculated from formula.
C	43·393	43·44
H	5·863	5·88
O	50·744	50·68

The only grounds presented in Prof. Sacc's paper for believing that the substance analyzed by him was pectic acid, are its appearance, its ready solubility while yet moist in ammonia, and its property of being precipitated from this solution by acids. Its composition is not such, for the quantity of hydrogen it contains is much greater than that found by any investigator in the substance acknowledged as pectic acid. The mean results of Chodnew's analyses of this acid, to which those of Prof. Sacc most nearly approach, are as follows—for convenience of comparison, Prof. Sacc's results are given in the second column, my own in the third:

C	42·22	41·93	43·39
H	5·21	5·93	5·86
O	52·55	52·14	50·75

Chadnew's formula is $C_{28} H_{20} O_{26} = C_{14} H_{10} O_{13}$.
Prof. Sacc's " " $C_{14} H_{12} O_{13}$.

The results of my own analyses of the substance from wood differ from those expressed by the latter formula, principally in the larger amount of carbon found; they differ also as widely from those obtained in any analysis of pectic acid. My further reasons for believing that the substance is not such, are, first, its different behavior on washing with alcohol; second, its insolubility in boiling water; third, the form of the precipitate obtained from a solution in excess of alkali; and finally, the fact that while pectic acid is partially transformed into mucic acid on being boiled with nitric acid, this is not the case with the substance under consideration.

My further conclusion from the investigation is that the real formula of the new acid is $C_{16} H_{13} O_{14}$.

Art. V.—*On the Navicula Spencerii;* by Warren De la Rue.

(In a letter to the Editors, dated London, August 28, 1849.)

Some time since, my attention was called to an article, in your Journal, for March, 1849, from the pen of Prof. J. W. Bailey, entitled, "Some remarks on the Navicula Spencerii, and on a still more difficult test object;" as this article contains some strictures on the description* of the markings on this Navicula observed by Mr. Marshall and myself, I trust, you will allow me an opportunity of replying to Prof. Bailey, in your valuable Journal.

I avail myself of this opportunity to correct Mr. Quekett, with respect to the nature of the markings observed by us;—he says, "Mr. De la Rue has further made out that the dots are not projections from the surface, but are either perforations or depressions;"—now this is precisely the reverse of what I wished, but apparently failed, to convey to Mr. Quekett, in a conversation I had with him, respecting this and some others of the Naviculaceæ; the markings of some I hold to be depressions, but those of N. Spencerii to be wart-like prominences.

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* See Quekett on the use of the Microscope, page 440 and plate ix.

With this correction, I proceed to answer Prof. Bailey, first premising, that I bear most willing testimony to the strong feeling of justice and absence of national prejudice, which pervades all the letters written by that gentleman to my friend, Mr. Marshall, whenever he speaks of the labors of English opticians; likewise the absence of any wish to eulogize Mr. Spencer's productions, at the expense of others. It is not, perhaps now, an unfitting occasion, to state that English microscopists have, during a long period, been much indebted to the kindness and zeal of Prof. Bailey, furnishing them, through the medium of the gentlemen favored by his correspondence, with any new objects, his investigations might have brought to light. I mention this, in order to show that the highest esteem is entertained by the English microscopist for Prof. Bailey, and that it is unlikely that he would be charged directly or indirectly, "with underrating the English microscopes," or with any *wish* to "overrate the merits of Mr. Spencer's, or the difficulties of N. Spencerii as a test object;" more especially by those who have, like myself, had an opportunity of seeing portions of his correspondence relating to the subject.

As I hold, that the difficulty of the N. Spencerii has been unwillingly overrated, if the exhibition of its markings, as mere lines, be the only test of the powers of an object glass, I should be wanting in candor, if I did not record my opinion.

Not having taken part in the correspondence quoted by Prof. Bailey, I do not, in any way, hold myself answerable for the opposite impressions, it may tend to convey; it is not however a question, of what this or that observer is capable of showing with a given object glass, but what the glass can really be made to do. With one exception, I believe that none of the object glasses, spoken of by Prof. Bailey's London correspondent, were incapable of resolving the Navicula; the fairness of which reference I hope to establish. The exception I allude to, is Mr. Marshall's own glass, which, on careful examination, we found to be defective; and, in consequence, it was placed in the hands of the maker.

I will now as briefly as possible, state my acquaintance with the N. Spencerii, in order to show that any difficulty in resolving its markings, was not due to the object glasses possessed by the "Londoners."

It was only subsequently to the letter, dated 2nd June, 1848, quoted by Prof. Bailey, that I heard of the Spencerii, when Mr. Marshall mentioned to me, that he had received a most difficult object from America, which he would be glad of an opportunity of examining with me, as he could make nothing of it; an opportunity soon presented itself and we met at my house.

The object alluded to, was a slide of the N. Spencerii mounted in balsam, and sent over to Mr. Marshall by Prof. Bailey; two rings marked with a diamond, indicated two objects to be examined. The test having been illuminated with oblique light, from a lamp with and without the use of the mirror, was examined with a Ross's $\frac{1}{12}$th having only an aperture of 90°; this objective had been in my possession for some years, and was far inferior to those Ross was furnishing, with an aperture from 115° to 120°.*

Very little difficulty was now experienced in bringing out separately both sets of lines most distinctly, by illuminating in two different directions. We now attempted to examine the object with a Ross's $\frac{1}{12}$th, of 110°; but, owing to the thickness of the covering-glass, we could not get it on the object; as it was an only specimen we did not deem it advisable to change the covering-glass.

In consequence, Mr. Marshall undertook to write to Prof. Bailey, to request the favor of a little of the deposit, in order to mount fresh specimens, both dry and in balsam; the former with the view of studying the nature of the markings under the most favorable circumstances.

I believe I am right in saying that the first parcel which arrived was lost by an accident; at all events, it was not until the 14th of August, 1848, that Mr. Marshall had prepared specimens with covering-glass sufficiently thin for our large aperture $\frac{1}{12}$ths. On that day he wrote to me, "I have prepared two sides for you, one in balsam and the other dry, they have been both evaporated on the covering-glass which is exceedingly thin. * * * * I should like to go over the slides I have prepared, and particularly the dry mounted one, for the purpose of resolving it, if we can, by direct light. The Bank is so disturbed by the heavy omnibuses that your own quiet room is the best place, and if you should be disengaged some evening, I will go to your house, taking with me the slides and two or three others which I have for your cabinet."

Previously to his writing the above, we had succeeded in showing the markings with a large aperture $\frac{1}{4}$th inch objective of Ross's make, having an aperture of 80°. This fact was communicated verbally to the Microscopical Society, on one of the ordinary meetings, by Mr. Marshall.

Having again met at my house, we examined the dry and balsamed specimens; as we were well acquainted with the N. angulata, we at once proceeded with the view of ascertaining whether the N. Spencerii had similar dot-like markings; to determine this was a matter of greater difficulty than to resolve them into cross lines; but, after working for about an hour, the dry specimen was most satisfactorily resolved; and the dots exhibited on that occasion we did not succeed so well in showing, in the markings of the balsamed specimen. Direct illumination was used on this occasion, the illuminator being a $\frac{1}{4}$th inch object glass of 60°.

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* Mr. Ross, some time back, succeeded in making a twelfth with an aperture of 135°, in which the aberrations were well corrected. It is now in the possession of Dr. Leeson.

It appears that Mr. Marshall communicated in his letter of the 18th August, 1849, quoted by Prof. Bailey, that the dry specimen had been resolved into dots, and that ere long, he hoped to report the resolution of the balsamed specimen; this has been since repeatedly accomplished, but, whether recorded or not by Mr. Marshall, I cannot say.

I feel I am warranted in pronouncing *the markings of the Navicula Spencerii shown as lines, not to have been a difficult test for the object glasses of the "Londoners"* at the time of its arrival. It appears it was so, however, for some observers, and Prof. Bailey drew from his correspondents' letters the very fair inference, that the instrument was at fault and not themselves; he supports, however, my conclusion, when he states that the microscopes which, in the hands of their possessors, had failed to show the markings, readily resolved them in his.

With regard to the measurements of the distance of the markings, fixed by Prof. Bailey at values so widely different from my own, I have to remark, that I delayed answering his communication, in order to repeat my measurements with every possible precaution.

Prof. Bailey states the distances of the markings to be from $\frac{1}{150000}$th to $\frac{1}{500000}$th of an inch, whilst I assign to them a value of from $\frac{1}{45000}$th to $\frac{1}{50000}$th of an inch, (from centre to centre of the spots.) That the measurement given by me was not very wide of the truth, I will proceed to show, and I believe that Prof. Bailey, on reference to his notes or on repeating the measurement, will trace out the cause of the error he has fallen into.

My previous measurements were made with a ruled micrometer, used with a positive eye-piece, the value of whose divisions had been rigorously estimated by comparison with a micrometer of $\frac{1}{5000}$th of an inch, placed on the stage of the microscope. I have now repeated the estimation by a different, and I believe a preferable, method to that I employed before, viz., by illuminating the object to show alternately the markings as cross and longitudinal lines, and then drawing them, by the aid of a small steel reflector, shown at page 129 of Mr. Quekett's work. Retaining the microscope in exactly the same position, I removed the object, and placed on the stage of the microscope first a micrometer of $\frac{1}{5000}$th of an inch which I sketched on the paper; having by comparison roughly estimated the value of the markings, I then selected two sets of lines from Nobert's test slide, according, as nearly as possible, with this estimate; the lines of the two selected were the $\frac{1}{45045}$th and the $\frac{1}{47468}$th of an inch apart from centre to centre, these were set off in the same way.

The drawing of the markings, that of the micrometer of $\frac{1}{5000}$th of an inch, and those of Nobert's series, were compared together by taking a sufficient number of lines in a pair of dividers, and the distance of the markings thus ascertained. This operation was repeated, first with an eye-piece, magnifying 1200 diameters, then with one magnifying 1900 diameters. The distances of the cross markings from two different sides of the shell, estimated with the first eye-piece, was $\frac{1}{45007}$th and $\frac{1}{47004}$th respectively, with the second eye-piece, the distances for the same part of the shell, were $\frac{1}{43007}$th and $\frac{1}{46062}$th respectively. The longitudinal markings in both cases I found to be $\frac{1}{54004}$th of an inch. All these values are from centre to centre, and are sufficiently concordant, amongst themselves and with those previously given, to establish my measurements beyond doubt. The difference in distance between the cross and longitudinal lines, accounts for the greater difficulty one experiences in resolving the latter.

Measurements of the markings of the hippocampus gave the following values: for the distance of the centres of the cross markings $\frac{1}{37037}$th of an inch and for the longitudinal $\frac{1}{32000}$th of an inch; these were fully confirmed by comparison with Nobert's lines of $\frac{1}{32175}$th and $\frac{1}{37537}$th of an inch.

In order that others may be able to judge of the reliance to be placed on the values here given, I subjoin the following measurements of some of Nobert's lines, and the real values assigned by himself; these were made without knowing at the time Nobert's values:

Lines to the inch (English).

De la Rue.	Nobert.	De la Rue.	Nobert.
11111	11261	32000	32175
13043	13056	37037	37537
15200	15426	40816	40950
17647	18163	43103	42982
20454	20475	45045	45016
23666	23461	47468	47619
27272	28153	50000	50000

I would wish here to record my admiration of the skill of Mr. Nobert, who has ruled at my request a series of progressive lines, fifteen in number, running from 11260 lines to 56300 lines to an inch, and a separate band on the same slide of 112613 lines to the inch, besides other series very useful to me in comparing with

Naviculaceæ; these have some of the finer series crossed at angles of 90° and 120° respectively, and afford a good control of the value of one's conclusions respecting the nature of their markings. All the straight bands, with the exception of the last, can be made out by oblique light with my quarter of 80° before alluded to. The last series of $\frac{1}{112813}$th of an inch I can see to be lined, on using a $\frac{1}{12}$th object glass of 110°, but up to the present moment, I have not satisfied myself that the lines I see do not comprise two of the real lines. It is, at all events, worthy of experimental inquiry, to ascertain whether the physical properties of light do not put a natural limit to our resolving lines so close as the $\frac{1}{126600}$th and the $\frac{1}{266666}$th of an inch, quoted by Prof. Bailey; the celebrated Fraunhofer maintained that this was the case.

After what I have said, in the commencement of this communication, it is hardly necessary for me to state that I quite agree with Prof. Bailey, that the markings on the Spencerii are due to the allinement of prominences; I moreover concur in his views respecting the difficulty of deciding on the real nature of the markings, on objects so minute as the Naviculaceæ. One thing is however quite certain, that a much inferior glass, provided it have a sufficient angle of aperture, will suffice to show even both sets of lines at one time, than that required to bring them out as distinct dots without any blue or fuzziness. Bringing out both sets of lines at once is to me a well know phenomenon and quite different from the exhibition of markings by the image of a luminous object brought to focus in the plane of the object.

I must not be understood to affirm positively that Mr. Spencer's glasses will not do this, for I have never had an opportunity of examining one. On a late occasion a recent objective of Spencer's was however tried in my presence by the possessor on the N. angulata, but, though very excellent, it did not equal our English twelfths. Judging from Mr. Spencer's production, I feel assured that he is a man of too much merit to feel hurt at this criticism.

As I am unacquainted with Mr. Spencer's new test, I cannot speak as to its difficulty.

I would recommend* Natchet's condensing prism to the attention of all microscopists engaged in the examination of lined objects; it brings out the dot-like markings of the N. Spencerii with remarkable force, even in balsamed specimens. It consists of a prism, which, by two internal reflections and the inclined convex surface of its summit, condenses light at an angle of 35° on to the object. By mounting it in such a way that it may be rotated as well as brought to a focus, it answers all the purpose of a Legg's stage.

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* Mr. Natchet is an optician resident in Paris.

The feat with the hand tube mentioned by Dr. Bailey is surely rather a *tour de force* for the observer, than for the objective of the "Yankee Backwoodsman;" who, if report speaks truly, is a highly educated American gentleman, with talents and acquirements sufficient to remove any obstacles to the attainment of a position amongst the first opticians of his day.

ART. VI.—*Caricography;* by Prof. C. DEWEY.

(Continued from vol. viii, p. 350.)

No. 241. *C. lupuliformis*, Sartwell, *lupulina*, Muh., var. *polystachya*, Schw. and Tor. in Mon. Cyp. Tor., No. 132, p. 420.

Spicis staminiferis 1–3 oblongis, suprema longo-pedunculata squamas lanceolatas acutas habente, inferis perbrevibus sessilibus subbracteatis: pistilliferis 3–5 longo-cylindraceis superne aggregatis subsessilibus, infima nunc subdistante nunc remota exserte longo-pedunculata, folioso-bracteatis sublaxifloris; fructibus *tristigmaticis* globoso-ovatis inflatis teretibus scabrostratis sessilibus striatis glabris bicornibus, squama ovata cuspidata plusquam duplo longioribus.

Culm 2–3 feet high, erect, large, smooth on its angles, with long leafy bracts and with the lanceolate rough-edged and reticulate leaves surpassing the culm; staminate spikes 1–3, cylindric, slightly bracteate, with long lanceolate scales, the upper spike 2–4 inches long and pedunculate, the lower short and sessile and rarely androgynous; pistillate spikes 3–5, cylindric, 2–3 inches long, clustered above and nearly sessile, erect or slightly diverging, the lowest often quite remote and long exsertly pedunculate, all with leafy bracts and the lower sheathing; stigmas three; fruit globose-ovate, tapering into a long and serrulate and two forked beak, quite sessile; pistillate scale *ovate*, cuspidate, scarcely half as long as the fruit; achenium rhomboid *with a prominent node on the angles.*

Differs from *C. lupulina*, Muh., in its much longer and more numerous spikes, its globose ovate fruit, closely sessile, with its *serrulate* beak, its *ovate* scale, its rhomboid and *nodose* achenium, its nearly bractless staminate spikes, its general and glabrous appearance, and its coming to maturity near a month later. It seems not to be *C. gigantea*, Rudge, which has been considered another form of *C. lupulina.* In several respects the plant now described differs from these two like *C. Grayii*, Carey, from *C. intumescens*, Rudge.

Found about lakes, ponds and marshes in the northern states and Canada—not very common.

No. 242. *C. torta*, Boott. *C. acuta*, Schk. Tab. Ff, fig. 92 *b*.

Spica staminifera unica, interdum binis, cylindracea; pistilliferis ternis vel pluribus longo-cylindraceis sublaxifloris, basin parvis et sparsifloris, apice substaminiferis, superne sessilibus, inferne pedunculatis, divergentibus vel recurvatis; fructibus *distigmaticis* ovatis utrinque convexis, superne teretibus acuminatis et interdum recurvatis, squamam lanceolatam subobtusam interdum superantibus sæpe subæquantibus.

Culm near two feet high, erect, rather slender, triquetrous, scarcely rough on the edges, leafy towards the base; leaves lanceolate, smooth or soft, shorter than the culm; lower bract long as the culm, the upper shorter or nearly wanting; pistillate spikes usually three, sometimes four, long, slender, sometimes enlarging upwards, very sparse-fruited towards the base of lower spikes, recurved in maturity, and the lower pedunculate, the upper sessile; stigmas two; fruit ovate, convex on both sides, short or long tapering upwards to a point and some recurved; pistillate scale lanceolate, obtusish, narrower than the fruit, black with a green keel, sometimes longer, but more commonly a little shorter than the fruit; culm and leaves light green.

Grows in wet places over the United States. This plant differs much from the European and American form of *C. acuta*, L., and was properly described as a distinct species by Dr. Boott, the distinguished secretary of the Linnæan Society. It is probable that Schk. derived his figure, No. 92 *b*, from American specimens, and in his time he might reasonably consider the plant to be a variety of *C. acuta*, L. It is not *C. acuta* var. *sparsiflora*, D.

ART. VII.—*On the Nitrates of Iron and some other Nitrates*; by JOHN M. ORDWAY,* of the Roxbury Laboratory, Mass.

SESQUINITRATE of iron may be easily obtained in the form of crystals by taking advantage of the fact, that this salt is almost insoluble in cold nitric acid.

When metallic iron is gradually added to nitric acid of sp. gr. 1·29, copious red fumes are given off, and the liquid assumes a greenish hue, till nearly ten per cent. of iron has been taken up.

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* The author observes as follows in a letter relating to his investigations:—

Those who have occasion to prepare liquid nitrate of iron in the large way, are often troubled, in cold weather, by the deposition of crystals before the requisite quantity of iron has been dissolved. Concerning the true nature of these crystals, I have been unable to gather any definite information from all the works of chemistry within my reach. Indeed, respecting the compounds of nitric acid and peroxyd of iron, though of some importance in the arts, the books give but vague accounts, and those not altogether correct. Thus "azotate ferrique" is described in Hoeffer's Dictionaire de Chimie et de Physique, as "d'un brun rouge, *incrystallisable*, deliquescent, soluble dans

A farther addition changes the color to a dark red, and if the action be continued still longer, a rusty precipitate forms. If we stop short of this last point, and add to the product its own bulk of nitric acid of sp. gr. 1·43, an abundant crop of crystals will be deposited on cooling below 60° F. The same result may be attained by evaporating the greenish liquid, and adding acid enough to insure a considerable excess, before setting the solution aside to cool. If the first crystals are brown, they may be purified by redissolving in nitric acid, with the aid of a gentle heat, and allowing again to crystallize.

The crystals thus obtained, have the form of oblique rhombic prisms, which are either colorless or of a delicate lavender color, but when dissolved in water, yield a yellowish brown solution. They are somewhat deliquescent and very soluble in water; while at a temperature below 60° F., a weighed quantity was not wholly taken up by over twenty parts of nitric acid of sp. gr. 1·37.

At about 117° F., this salt melts into a clear, deep red liquid, which in one trial remained fluid till cooled to 83° F., when the heat developed by solidification, quickly raised the thermometer to 116½°.

The composition of this substance, as indicated below, affords reasons for supposing that by its admixture with a bicarbonate, an intense cold might be produced. Such proved to be the case, for when two ounces of the bruised crystals were stirred up with one ounce of pulverulent bicarbonate of ammonia, the thermometer introduced fell from 58° to −5° F. Previous cooling is attended with an increase of effect.

These experiments being very tangible, would furnish excellent illustrations of the principles of latent heat.

A small quantity of the melted nitrate kept hot for several hours by means of a water bath, yielded a perfectly dry, dark brown, deliquescent powder, containing some water and one half the original amount of acid. More acid may be expelled by a moderate heat, but to drive off the last portions, requires a temperature approaching to redness.

The well drained crystals afforded by precipitation with ammonia 19·8 p. c. of peroxyd of iron, and 100 grs. boiled with carbonate of baryta, gave a liquor which with sulphuric acid

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l'eau et dans l'alcool." While Berzelius incidentally mentions that "*Vauquelin* ayant laissé de l'acide nitrique en contact avec de la battiture de fer, trouva, au bout de plusieurs mois, des *cristaux incolores*, qui affectaient la forme de prismes rectangulaires à quatre pans." Perhaps the *rectangulaire* was a mistake, for in several experiments, I have obtained forms variously modified but all referable to the oblique rhombic system. In one huge crystal which had been many months in forming, the angles included between the long lateral faces of the prism, were found to be 101° and 79° nearly.

Numerous experiments made with a view to obtain more light on the subject, have afforded some results which may not be altogether uninteresting, and are, I trust, partly new and singular.

yielded 86·5 grs. of sulphate of baryta, indicating 40·104 p. c. of dry nitric acid. Hence the formula is probably $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}_3\,\overset{\cdots}{\mathbf{F}\mathrm{e}}+18\dot{\mathrm{H}}$, which would give in 100 parts;—nitric acid 40·095, peroxyd of iron 19·819, water 40·086.

Basic nitrates —A liquid is used in cotton dyeing, which is prepared by adding iron turnings to aquafortis till the solution assumes a very dark red color. A fair sample of this solution, of sp. gr. 1·478, was found by analysis to contain five equivalents of nitric acid to two equivalents of sesquioxyd of iron. A portion of the same placed in contact with metallic iron, remained clear until nearly enough iron had been taken up to form a sesquibasic nitrate, ($\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}_2\,\overset{\cdots}{\mathbf{F}\mathrm{e}}$,) when a rusty precipitate began to appear, whose exact nature it is difficult to determine.

A full sesquibasic nitrate was formed by adding crystals of the nitrate to the proper quantity of freshly precipitated oxyd of iron. And proceeding by the same means, but with slow and cautious steps, as into an unknown region, I was successively astonished by the discovery of soluble basic nitrates containing to three equivalents of acid, two, three, six, eight, twelve, fifteen, eighteen and twenty-four equivalents of base, respectively; and then, from the slowness with which the union took place in the last, I supposed the limit reached. Yet this liquid was found to bear the addition of a small quantity of lime water, without change.

On arriving at these remarkable results, the question naturally came up, whether there were any chances of error. But on examination, no foreign substance was detected, and the analyses of the six, twelve, fifteen, and twenty-four basic compounds, agreed so nearly with the syntheses as to remove all doubts.

Which of these bodies have claims to be regarded as true atomic compounds, there seems to be no clue but analogy to determine. They all form intensely deep red liquids, which are not altered by dilution, nor by brisk boiling, provided the evaporation be not carried too far. By spontaneous evaporation they leave a very dark red powder, perfectly soluble in water. That left by the dodecabasic nitrate, was not deliquescent, and lost 30 p. c. of its weight by ignition. Hence its empirical composition would be $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}\,\overset{\cdots}{\mathbf{F}\mathrm{e}}_4+9\dot{\mathrm{H}}$.

When cotton cloth is dipped in any of these solutions, and dried, the oxyd of iron becomes permanently attached. Indeed the adhesion of the base to cotton fibre, renders filtration through paper exceedingly slow.

Since spring and river water, and the solutions of most salts, are incompatible with the twenty-four basic nitrate, it was found necessary to use an abundance of distilled water for washing the oxyd used in its preparation. So intense was the color of this liquid that, though containing only 3·4 p. c. of oxyd of iron, two drops imparted a perceptible tinge to a pint of distilled water. In trying the reactions of various subtances with it, all the iron appeared to be immediately thrown down by muriate of ammonia, chlorid of sodium, iodid of potassium, chlorate of potash, sulphates of soda, lime, zinc and copper, nitrates of potash and soda, and the acetates of baryta and zinc. Precipitates formed more slowly with the nitrates of ammonia, magnesia, baryta and lead. Tartrate of soda furnished a precipitate soluble in ammonia. Ferrocyanid of potassium gave a dark peat-brown precipitate without the least tinge of blue. Ferrocyanid of potassium gave likewise a rich peat-brown precipitate. Tincture of galls afforded dark brown flocks, and on standing some time, the supernatant liquor turned black. Alcohol, acetate of lead, acetate of copper, cyanid of mercury, nitrate of silver, and arsenious acid caused no change.

With the tribasic nitrate, muriate of ammonia, chlorid of sodium and nitrate of soda produced no effect; while the sulphates threw down all the iron, prussiate of potash struck a blue color, and tincture of galls gave a black.

Nitrate of Alumina.—Nitrate of alumina crystallizes from a concentrated and somewhat acid solution, in colorless oblique rhombic prisms, whose height is generally small in proportion to their width. They are deliquescent, and very soluble both in water and in nitric acid. The crystals, like those of the other sesquinitrates, can be best dried by spreading them on an absorbent surface, and placing the whole under a bell glass, along with a shallow vessel containing sulphuric acid.

The salt was found to melt at 163° F., into a clear colorless liquid, which began to crystallize when cooled down to 147½°, the thermometer rapidly rising, at the same time, to 102°. The melted mass parts with its acid much less rapidly than the nitrate of iron. One ounce of the powdered salt mixed with one-half ounce of bicarbonate of ammonia, lowered the thermometer from 51° to −10° F.

100 grs. of pretty dry crystals, yielded by ignition 13·7 grs. of alumina. Distillation with sulphuric acid gave 42 p. c. of nitric acid, and by boiling with carbonate of baryta, 42·42 p. c. was separated. The numbers corresponding to $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}_3\,\overset{\cdot\cdot\cdot}{\mathbf{Al}} + 18\dot{\mathrm{H}}$, would be in 100 parts:—nitric acid 43·17, alumina 13·68, water 43·25.

Nitrate of alumina appears to form with the hydrate, a series of salts similar to the basic nitrates of iron. But they have not as yet been fully examined.

Nitrate of Chrome.—Nitrate of chrome crystallizes with difficulty in warm weather, but I have succeeded in obtaining two crops, one of them presenting the form of the oblique rhombic prism, and the other a very deeply modified variety of the same. These crystals have the changeable purple color peculiar to the salts of chrome, and their solution in water is of the same hue while cold, but becomes green when heated.

This salt fused at about 98° F. into a deep green fluid, which began to assume the solid state when cooled to 75°, the thermometer rising thereupon to 96°. If heated to redness, it undergoes complete decomposition, leaving a bulky oxyd of a beautiful green color.

The composition of nitrate of chrome was found by analysis to be: nitric acid 39·7 p. c., oxyd of chrome 19 p. c. Calculation from the formula $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}_3\,\overset{\cdots}{\mathrm{Cl}}+18\,\dot{\mathrm{H}}$, gives: nitric acid 40·44, sesquioxyd of chrome 19·13, water 40·43.

No experiments have been made on the basic salts.

Roxbury, Mass., Oct. 1st, 1849.

Art. VIII.—*A description of two additional Crania of the Engé-ena, (Troglodytes gorilla, Savage,) from Gaboon, Africa;* by Jeffries Wyman, M.D.

Read before the Boston Society of Natural History, Oct. 3d, 1849.

The evidence now existing of a second and gigantic African species of man-like ape, as appears from published reports, consists of the following remains:—1. Four crania in the United States, two males and two females, of a large portion of a male skeleton, and of the pelvis and of some of the bones of a female. These were the first remains of this animal which had been brought to the notice of naturalists, and were described in the Boston Journal of Natural History.*—2. Three other crania subsequently discovered exist in England and have been made the subject of an elaborate memoir by Prof. Owen, in the Transactions of the Zoological Society of London.†—3. Quite recently, Dr. George A. Perkins, for many years an able and devoted laborer in the Missionary enterprise at Cape Palmas, W. Africa, has brought to the United States, two additional crania, one of which is deposited in the Museum of this Society, and the other in that of the

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* See Proceedings of the Boston Soc. Nat. Hist., Aug. 18, 1847; also a description of characters and habits of Troglodytes gorilla, by Thomas S. Savage, M.D., Corresp. Memb. Bost. Soc. Nat. Hist., and of the Osteology of the same by Jeffries Wyman, M.D., Boston Journ. Nat. Hist., Vol. v, p. 417, 1847.

† Osteological Contributions to the Natural History of the Chimpanzées, (*Troglodytes*, Geoff.,) including the description of the skull of a large species, (*T. gorilla*, Savage,) discovered by Thomas S. Savage, M.D., in the Gaboon country, West Africa, by Prof. Owen, F.R.S., F.Z.S., &c. Read Feb. 22, 1848. Trans. Zoolog. Society of London, Vol. iii, p. 381, 1849.

Essex Institute in Salem. Both of these have been referred to me for the purposes of description, and it is the object of this communication to notice the more important anatomical features of this the largest of African Quadrumana, with regard to which additional information is desired.

Cranium I. Male.—This belonged to an adult Engé-ena,* as is evident from the fact that the teeth are all perfectly developed; yet not to an old one, as appears from the circumstances that the points of the molars are but very slightly worn, and the crests on the top of the head and occiput are but imperfectly formed. Its size as well as that of all the other crania of this species which have been measured, when compared with that of *T. niger* (Chimpanzée) and a well marked Negro head, may be learned from an inspection of the following table.

Table I.—Measurements of the crania of *T. gorilla*, of *T. niger* and of the cranium of a native African in inches and tenths.—Nos. 2, 6, 7 and 8 are in inches and lines.

	Troglodytes gorilla.						T. niger.		Man
	Males.				Females.		Male.	Female.	
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Length of head from occiput to edge of incisive alveolus,	11·2	11·4	11·0	10·2	9·10	9·0	8·0	7·9	9·6
Greatest breadth across post-auditory ridges,	6·1	6·10	6·4	5·9	5·2	5·6	5·0	4·6	5·4
Smallest diameter behind orbits,	2·5	3·3	2·9	2·7	2·5	2·4	2·6	2·8	3·4
Diameter of face across zygomatic arches,	6·5	6·6	7·0	6·4	5·5	5·3	5·0	4·8	5·7
Diameter of face outside the middle of the orbits,	4·9	6·0	5·8	5·7	4·3	4·8	4·3	4·0	4·9
From occiput to most prominent part of supra-orbitar ridge,	7·3	..	7·6	6·5	6·5	6·1	5·4	5·3	7·2
From sup. orb. ridge to edge of incisive alveolus,	4·8	..	5·7	6·0	..	..	4·0	4·4	3·5
Breadth of zygomatic fossa,	1·7	1·8	1·9	1·8	1·4	1·5	1·3	1·1½	1·1
Inter-orbitar space,	1·1	1·3	1·2	1·1	1·0	1·1	0·8	0·7	1·2
Transverse diameter of orbits,	1·5	1·9	1·8	1·6	1·4	1·6	1·5	1·6	1·6
Vertical " "	1·6	1·7	1·6	1·6	1·4	1·7	1·3	1·3	1·3
Length of bony palate from outer edge of incisive alveolus,	3·7	4·1	..	4·3	3·4	3·3	..	..	1·7
From anterior edge of foramen magnum to outer edge of incisive alveolus,	7·2	..	..	7·4	3·5	..	..	..	..

(Crania I. and V. were the ones brought by Dr. Savage to this country—II, VI, VII. and VIII. are the crania described by Prof. Owen; III. and IV. are the crania which were obtained by Dr. Perkins—IX. the cranium of a Negro born in Africa in whom the characteristics of the race were well marked, and which belongs to the Cabinet of the Boston Soc. for Med. Improvement. See Catalogue of Society's Cabinet, Specimen No. 61.)

This cranium does not agree with that figured by Prof. Owen in his memoir (Pl. lxi.) in the exclusion of the orbits from view by the prominent malar bones when the skull is seen in profile, but as was the case in those discovered by Dr. Savage, the nasal bones are wholly, and the orbit in part brought into view. In none of them is it more excluded than in the first figures of our memoir. The great ridges above the orbits, which are so widely developed in *T. niger*, are still more so in the present species, and in the specimen now under consideration sustain the former statements with regard to them. Prof. Owen remarks in connection with them, "the prominence of the whole supra-orbitar ridge reaches its maximum in the present species and forms the most marked distinction in the comparison of its skull with that of man." (Memoir, p. 405.)

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* Prof. Owen designates *T. gorilla* as the "Great Chimpanzée." The Mpongwes (natives inhabiting the banks of the Gaboon) call this species the Engé-ena, a more desirable name, as the term Chimpanzée has been always associated with the black or smaller species.

Sutures.—I have shown in a former communication from an examination of several crania of the Chimpanzée, that nearly all the sutures are completely obliterated early during the adult period.* From a careful examination of the six crania of the Engéena to which I have had access, there is every reason to believe that an early coössification takes place in them also. In the skull now under consideration, which it is to be remembered, has not long passed the adult period, the frontal, the sagittal, the coronal, the squamous portion of the temporal sutures, all those in the temporal fossa as well as the transverse portion of the lambdoidal are no longer persistent. The crania which have been examined by Prof. Owen, or some of them at least, indicate an opposite state of things. To ascertain, therefore, the value of cranial sutures as specific signs, it is quite obvious, that a large number of crania of different ages must be critically examined.

Inter-maxillaries.—These bones so important as zoological indications are completely coössified with the maxillaries and with each other. No indication of a suture exists between them and the last mentioned bones either on the external surface below the nasal openings, or in the roof of the mouth. I was not able to find any indications of the ascending portion of the intermaxillary bone which articulates with the nasals, until led by Prof. Owen's description to make a more careful search. Although externally there was no mark which would lead an anatomist to infer its existence, yet within the nasal cavity at a short distance from its margin, the edge of the process was easily detected, it not having become coössified in that region with the adjoining bone.

The extension of the intermaxillary upwards as far as the ossa nasi, so as to form the lateral walls of the external nasal orifice, as was indicated in a specimen of Chimpanzée, examined by Prof. Owen, is still obvious in a young skull of the same species in my possession, where it reaches the nasals by a slender and pointed process. The enlargement of this process in the Engé-ena,* so as to form an extensive articulation with the nasal bones, inasmuch as it is a repetition of what exists in the lower quadrumana and nearly all the mammalia, must be regarded as an index of degradation.

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* Boston Journal of Natural History, April, 1843.

Ossa Nasi.—Prof. Owen, in his memoir† on the Engé-ena, in speaking of the sutures between the nasal maxillary and intermaxillary bones, says, "it is remarkable indeed since these sutures remain so distinct in the adult female skull and the two adult male skulls, in the Bristol Museum, that no trace of them should have been detected in either of the four skulls taken to America by Dr. Savage, in which the ossa nasi are described as being firmly coössified with each other and the surrounding bones," (the concluding words of the above sentence he does not quote, viz., "but their outline is sufficiently distinct.") In the cranium brought by Dr. Perkins, the consolidation of these bones is equally complete and their outline is but indistinctly traceable.

In the crania formerly described, the ossa nasi form, on the median line, a sharp elevation or crest; in the specimen figured by Prof. Owen, (Pl. lxii,) this is represented by a more rounded and convex ridge, "and thus offering a feature of approximation to the human structure which is very faintly indicated, if at all, in the skull of the *T. niger*."‡ In the cranium now under consideration, when compared with the Plate above referred to, the convexity is still more remarkable, and will bear a more favorable comparison with the "bridge" of the nose in some of the human races.

The expansion of the nasals above, where they are interposed between the frontals, as described by Prof. Owen, was overlooked in my former description, only very faint indications of sutures remaining. On a more careful examination, the outline of the portion of bone interposed between the orbitar process of the frontals is indistinctly traceable in the male skull discovered by Dr. Savage, and in both of the crania brought to this country by Dr. Perkins; and in all of them, on a line with the upper extremity of the ascending process of the superior maxillary bone, at the point where the nasal bones become the most contracted, there exists an equally strong indication of a transverse suture, which separates the portion marked 15′ in Prof. Owen's figure from the true nasals, and equally distinct indications of this suture exist in his figure just referred to. Thus we have strong ground for the supposition that the part marked 15′ by Prof. O. may not be the expanded portion of the nasals but an additional osseous element intercalated between the frontals. In this event my original description of the ossa nasi, "as having a more triangular form than in the Chimpanzée, the apex being more acute," still holds good. If, however, the bone referred to prove to be a portion of the nasals, we shall have in this another index of inferiority to the Chimpanzée, as it is a repetition of what is met with in the lower quadrumana.

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* This is very distinctly shown in Pl. lxii. of Prof. Owen's Memoir.

† Op. cit., p. 420.

‡ Op. cit., p. 398.

Teeth.—The molars alone remain, the incisors and canines having been lost. The length of the grinding surface of the molar teeth is 2·9 inches, the two rows being nearly parallel to each other. This is true of the alveoli, though the crowns slightly diverge from each other posteriorly in consequence of an inclinatiom outwards. Nearly all of the cusps of the teeth are perfect, those of the first molar being the most worn, as would naturally be expected, it being the first which is protruded. The inner cusps of this tooth are worn nearly to the base; the outer are but slightly abraded, and the same is the case with the inner cusps of the second molar; with these exceptions the points of the different crowns of the molars and premolars are entire.

In comparing their grinding surface with that of the human jaw, one cannot but be struck with its greater extent, with the much greater development of the outer row of cusps, and the high ridge which on all three of the molars connects the outer row of cusps with the anterior inner cusp. In these respects as well as in having the third molar, or the "dens sapientiæ," of equal size with the others, the Engé-ena recedes from the Chimpanzée and still farther from man.

In the left upper jaw and on the level with the lower extremity or the pterygoid process, a supernumerary molar existed, still buried in its bony cavity, the roots not having as yet been developed. In the configuration of its grinding surface it did not conform with either of the other teeth.

Bony Palate.—By reference to the table of measurements, it will be seen that the space between the incisive alveoli and the edge of the hard palate is much greater proportionally than in the Chimpanzée. The median suture has disappeared and only slight indications remain of a former suture between the maxillaries and the ossa palati. The emargination on the middle of the edge of the palate is much less distinct than in either of the other specimens which I have examined, or than in that figured by Prof. Owen.

The *Vomer* has the same thin and delicate structure as in the other crania and does not meet the ossa palati at the posterior edge.

Cranial capacity.—In studying the anatomical characters of this and the allied quadrumana with reference to their zoological position, nothing can be more desirable than to have accurate knowledge with regard to the structure and dimensions of the brain, for this may be regarded as one of the most important of all the tests of elevation or degradation. The bodies of the adult anthropoid animals so seldom fall into the hands of the anatomist, that it becomes extremely difficult to accumulate observations on the actual condition of this organ. In the comparative study of human crania with reference to national peculiarities, much light has been derived from accurate measurements of their internal capacity. These may be readily obtained and form a very important substitute for the actual dimensions of the brain itself. In the subjoined tables I have given the results of the measurements of all the crania both of Engé-enas and Chimpanzées to which I have had access while writing these remarks, and as they have been repeated in each case several times over, they may be regarded as nearly accurate. The capacity of the third cranium is alone doubtful; a portion of the occiput having been destroyed, rendered exact measurement impracticable, though it is believed that the result can differ but little from the truth.

TABLE II.—Cranial capacity of adult Engé-enas.

		Cubic inches.
I.	Male from Dr. Perkins, ...	34·5
II.	Male from Dr. Savage, ...	28·3
III.	Male from Dr. Perkins, ...	28·0?
IV.	Female from Dr. Savage, . . .	25·0
	Mean of the four crania, ...	28·9½

TABLE III.—Cranial capacity of adult Chimpanzées.

		Cubic inches.
I.	Female, ...	26·0
II.	Female, ...	24·0
III.	Female, ...	22·0
	Mean capacity of three skulls, .	24·0
	Cranial capacity of young Chimpanzées.	
IV.	First dentition complete, ...	20·0
V.	First dentition complete but the sutures obliterated to a less extent than in the preceding, ...	18·0

The above results clearly indicate that there exists a wide range in the cranial capacity of the Engé-enas, amounting to nine cubic inches, when both sexes are included in the observation. While it would be desirable to have the measurements of a much larger number, we still have evidence for concluding, that in the Engé-ena, as in man,* the capacity of the cranium of the male is larger than that of the female; the smallest male skull of the Engé-ena measuring twenty-eight cubic inches, and the female only twenty-five cubic inches.

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* "Although many female brains exceed in weight particular male brains, the general fact is sufficiently shown, that the adult male encephalon is heavier than that of the female, the average difference being from 5 to 6 oz." From the examination of 278 male brains and of 191 females, "an average weight is deduced of 49½ oz. for the male and of 44 oz. for the female." Quain and Sharpey's, Quain's Anatomy; edited by Joseph Leidy, M.D., vol. ii, p. 185. Philadelphia, 1849.

In Table III, the three adults are females, and it is quite worthy of notice, that the internal capacity of these differs so little from that of the female Engé-ena, while at the same time the body of the Chimpanzée is so much smaller than that of the other species. By comparing the measurements given of the corresponding portions of the skeleton of the Engé-ena and Chimpanzée, it will be seen that a much wider difference exists between them, than exists between the dimensions of their respective brains.*

It is interesting to contrast the measurements of the cranial capacity of these members of the Quadrumanous group with that of some of the more prominent of the human races. The following table which is extracted from the general summary of the measurements of a vast number of crania, by Dr. S. G. Morton of Philadelphia, gives in cubic inches the average cranial capacity of the different races or groups there mentioned.†

TABLE IV.

RACES.	No. of skulls measured.	Largest capacity.	Smallest capacity.	Mean.	Mean.
Teutonic Race of CAUCASIANS.					
Germans,	18	114	70	90	90
English,	5	105	91	96	
Anglo-Americans,	7	97	82	90	
MALAY GROUP.					
Malayan family,	20	97	68	86	85
Polynesian family,	3	84	82	83	
AMERICAN GROUP.					
Toltecan Family.					
Peruvians,	155	101	58	75	81
Mexicans,	22	92	67	79	
Barbarous Tribes,	159	104	70	87	
NEGRO GROUP.					
Native African Family,	62	99	65	83	
Hottentots,	3	83	68	75	
Australians,	8	83	63	75	

These results are derived from a table which Dr. Morton has based upon the actual measurements of over 600 skulls. The smallest mean capacity is that derived from the Hottentots and Australians, which equals only seventy-five cubic inches, while that of the Teutonic races amounts to ninety cubic inches. The maximum capacity of the Engé-ena, is therefore considerably less than one half of the mean of the Hottentots and Australians, who give us the minimum average for the human races.

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* See Table of comparative measurements. Boston Journal of Natural History, vol. v, p. 417.

† Catalogue of Skulls of Man and the Inferior animals in the collection of Samuel George Morton, M.D., &c. 3d edition. Philadelphia, 1849.

Cranium II. Male.—This cranium belonged to an individual much older than the one described in the preceding pages, the inner row of cusps of all the molars having been worn to their bases. The same obliteration of the sutures had taken place, the malar bones are more tumid, rendering the edge of the lower and outer part of the orbit more rounded. The floor of the nasal orifice slopes gradually from the anterior extremity of the vomer to the edge of the incisive alveoli, and presenting a groove on the median line. In man, the intermaxillary bones form a projecting ridge on the median line both in and below the nasal orifice and at the middle of the border of this opening form the projecting "nasal spine," which is not met with in any of the lower animals, and is therefore *an anatomical character peculiar to man.* With regard to this conformation of the intermaxillary bones, the Engé-ena recedes farther from man than the Chimpanzée. Two infra orbitar foramina exist on each side. The crests are not so well developed as in the cranium just described. The occiput having been in part destroyed, the cavity of the cranium is completely exposed. A groove for the lodgment of the longitudinal sinus is well defined; "digital impressions," formed by the cerebral convolutions, exist, but not well marked, the *crista galli* is merely rudimentary and is represented by a very slight median ridge, the olfactory fossa is quite deep, the cribriform plate being on a level with the middle of the orbit. About five parallel groves for the lodgment of the branches of the dura matral artery exist on each side.

Zoological position of the Engé-ena.

With the knowledge of the anthropoid animals of Asia and Africa which now exist, derived from the critical examinations of their osteology, their dentition, and the comparative size of their brains by various observers, especially Geoffroy, Tiedemann, Vrolik, Cuvier, and Owen, it becomes quite easy to measure with an approximation to accuracy, the hiatus which separates them from the lowest of the human race. The existence of four hands instead of two, the inability to stand erect, consequent on the structure of a skeleton adapted almost exclusively to an arboreal life, the excessive length of the arms, the comparatively short and permanently flexed legs, the protruding face, the position of the occipital condyles in the posterior third of the base of the skull and the consequent preponderance of the head forwards, the small comparative size of the brain, the largely developed canines, the interval between these last and the incisors, the three roots to the bicuspid teeth, the laryngeal pouches, the elongated pelvis and its larger antero-posterior diameter, the flattened and pointed coccyx, the small glutæi, the smaller size of the lower compared with the upper portion of the vertebral column, the long and straight spinous processes of the neck, these and many other subordinate characters, are peculiarities of the anthropoid animals, and constitute a wide gap between these and the most degraded of the human races, so wide that the greatest difference between these last and the noblest specimen of a Caucasian is inconsiderable in comparison.

Whilst it is thus easy to demonstrate the wide separation between the anthropoid and the human races, to assign a true position to the former among themselves is a more difficult task. Mr. Owen in his earlier memoir, regarded the *T. niger* as making the nearest approach to man, but the more recently discovered T. gorilla, he is now induced to believe approaches still nearer, and regards it as "the most anthropoid of the known brutes."* This inference is derived from the study of crania alone, without any reference to the rest of the skeleton.

After a careful examination of the memoir just referred to, I am forced to the conclusion, that the preponderance of evidence is unequivocally opposed to the opinion there recorded; and after placing side by side the different anatomical peculiarities of the two species, there seems to be no alternative but to regard the Chimpanzée as holding the highest place in the brute creation. The more anthropoid characters of the *T. gorilla* which are re-referred to by Prof. O., are the following.

1. "The coalesced central margins of the nasals are projected forwards, thus offering a feature of approximation to the human structure, which is very faintly indicated, if at all in *T. niger*."† This statement is applicable to all the crania which I have seen, and especially to the two crania described in this paper. Nevertheless the extension of the nasals between the frontals, or the existence of an additional osseous element, is a mark of greater deviation from man.

2. "The inferior or alveolar part of the premaxillaries, on the other hand, is shorter and less prominent in *T. gorilla* than in *T. niger*, and in that respect the larger species deviates less from man."‡ The statement in the first portion of this sentence is certainly correct, but a question may be fairly raised on that in the second. The lower portion of the nasal opening in the Engé-ena is so much depressed, especially in the median line, that the intermaxillary bone becomes almost horizontal, and the sloping of the alveolar portion takes place so gradually that it is difficult to determine where the latter commences and the nasal opening terminates, and in this respect it deviates much farther from man than *T. niger*.

3. "The next character which is also a more anthropoid one, though explicable in relation to the greater weight of the skull

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* Op. cit., vol. iii, p. 414. † p. 398. ‡ p. 393.

to be poised on the altas, is the greater prominence of the mastoid processes in the *T. gorilla*, which are represented only by a rough ridge in the *T. niger*."*

4. The ridge which extends from the ecto-pterygoid along the inner border of the foramen ovale, terminates in *T. gorilla* by an angle or process answering to that called "styliform" or "spinous" in man, but of which there is no trace in *T. niger*.†

5. "The palate is narrower in proportion to the length in the *T. gorilla*, but the premaxillary portion is relatively longer in *T. niger*."‡

These constitute the most important if not the only characters given in Prof. Owen's memoir, which would seem to indicate that the Engé-ena is more anthropoid than the Chimpanzée, and some of these it is seen must be received with some qualification.

If on the other hand we enumerate those conditions in which the Engé-ena recedes farther from the human type than the Chimpanzée, they will be found far more numerous, and by no means less important. The larger ridge over the eyes and the crest on the top of the head and occiput, with the corresponding development of the temporal muscles, form the most striking features. The intermaxillary bones articulating with the nasals, as in the other Quadrumana and most brutes, the expanded portion of the nasals between the frontals,—or an additional osseous element if this prove an independent bone,—the vertically broader and more arched zygomata, contrasting with the more slender and horizontal ones of the Chimpanzée, the more quadrate foramen lacerum of the orbit, the less perfect infra-orbitar canal, the orbits less distinctly defined, the larger and more tumid cheek bones, the more quadrangular orifice with its depressed floor, the greater length of the ossa palati, the more widely expanded tympanic cells, extending not only to the mastoid process, but to the squamous portion of the temporal bones, these would of themselves be sufficient to counterbalance all the anatomical characters stated by Prof. Owen in support of the more anthropoid character of the Engé-ena.

When, however, we add to them the more quadrate outline of the upper jaws, the existence of much larger and more deeply grooved canines, molars with cusps on the outer side longer and more sharply pointed, the dentes sapientiæ of equal size with the other molars, the prominent ridge between the outer posterior, and the anterior inner cusps, the absence of a crista-galli, a cranial cavity almost wholly behind the orbits of the eyes, the less perfectly marked depressions for the cerebral convolutions, and above all, the small cranial capacity in proportion to the size of the body, no reasonable ground for doubt remains, that the Engé-ena occupies a lower position and consequently recedes further from man than the Chimpanzée.

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* Op. cit., p. 394. † p. 395. ‡ p. 395.

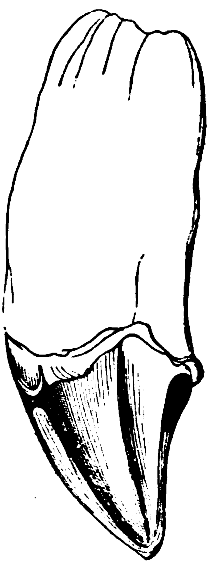
It does not appear that any other bones of the skeleton have as yet fallen into the hands of any European naturalist. A description of some of the more important of them will be found in the memoir above referred to,* in which it will be seen that there are two anthropoid features of some importance, which go to support the view advanced by Prof. Owen, and these are the comparative length of the humerus and ulna, the former being seventeen and the latter only fourteen inches, and in the proportions of the pelvis. This last is of gigantic size, and is a little shorter in proportion to its breadth than in *T. niger.*

While the proportions of the humerus and the ulna are more nearly human than in the Chimpanzée, those of the humerus and femur recede much farther from the human proportions than they do in the Chimpanzée, as will be seen by the following measurements:

	Humerus.	Femur.
Man,	15·0	18·5
Chimpanzée,	10·9	11·0
Engé-ena,	17·0	14·0

Thus in man the femur is three inches longer than the humerus, in the Chimpanzée, these bones are nearly of the same length, and in the Engé-ena the humerus is three inches longer than the femur, indicating on the part of the Engé-ena a less perfect adaptation to locomotion in the erect position than in the Chimpanzée.

Description of a canine tooth of a male Engé-ena.—In only one of the crania of the male Engé-enas which I have seen were the canines remaining; and these were so much abraded that they had lost to a great extent, their natural outline, and consequently their most striking and distinctive marks. In the females, as in the Chimpanzée and the Quadrumana, generally the canines are much less elongated than in the males. Among the bones first sent to this country by Dr. Savage, was the canine tooth represented in the annexed figure, which I was not able to identify, until an opportunity occurred of comparing it with Prof. Owen's descriptions of more perfect teeth. The crown is laterally compressed, the posterior edge being trenchant and its base provided with a prominent tubercle, which is doubtless rendered more conspicuous by the wearing of the edge beneath it. On its inner surface the crown is impressed with two strongly marked grooves, which extend from the base nearly to



Canine tooth of the Engé-ena—natural size.

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* Boston Journal of Nat. History, vol. v, p. 417.

its apex; and include between them a prominent rounded ridge. The following table gives the comparative measurements of two canines from the upper jaw of the Engé-ena, and one from that of the Chimpanzée. The figures in the first column relate to the tooth described above; those in the second and third to the measurements given by Prof. Owen,* the measurements being in inches and lines.

	T. gorilla.		T. niger.
Length,	2·8	2·8	2·0
Length of crown,	1·3½	1·3	0·10½
Breadth of base,	1·0	0·10	0 7
Thickness of do.	0·7½	0·7½	0·5½

The following note from Dr. G. A. Perkins to the author, dated Salem, Oct. 15, 1849, confirms the statements made by Dr. Savage, in his description of the habits of the Engé-ena, as to its ferocity and the fact of its attacking human beings.

"The two crania were received from a person on board a vessel trading in the Gaboon and Danger Rivers, W. Africa. They were obtained from the natives on the banks of the latter, by whom they had been preserved as trophies. From the gentleman who gave them to me, I learned that the killing of one of these animals was by no means a common occurrence. He describes the animal as being remarkably ferocious, even attacking the natives when found alone in the forests, and in one instance which fell under his observation, horribly mutilating a man who was out in the woods felling trees to burn. His shouts brought to his aid several other natives, who after a severe contest, succeeded in killing the Engé-ena. The man was afterwards in the habit of exhibiting himself to foreigners who visited the river and of receiving charity from them."

Art. IX.—*Notice of the cranium of the Ne-hoo-le, a new species of Manatee (Manatus nasutus) from W. Africa;* by Jeffries Wyman, M.D.

Read before the Boston Society of Natural History, November 7th, 1849.

The species of the genus Manatus, Cuv. which have been heretofore generally recognized, are only two in number, viz., 1, M. Americanus, Cuv. and Desm.; *Trichechus manatus*, Linn.; *le grand Lamantin des Antilles*, Buff. 2, the M. Senegalensis, G. Cuvier; *M. Africanus*, F. Cuvier; *Trichechus australis*, Shaw.† The late Dr. Richard Harlan of Philadelphia, has indicated a third species from E. Florida, to which he has given the name of M. LATIROSTRIS.[*] This species is recognized by Lesson and Fischer, but has been more recently denied by Blainville, who in referring to it in connection with two other species of the same group, (MANATUS, *Lamantin*, Blainville,) L. du tabernacle and L. de l'Orinoque, expresses himself, "ne regardant nullement comme suffisamment distinct."[†]

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* Trans. Zoolog. Soc. London, vol. iii, p. 395.

† Fred. Cuvier. Hist. Nat. des Cetacées. 8vo. Paris: 1836. Also Cyclopedia Anat. and Physiology, Article Cetacea. Lond.: May, 1836.

The existence of this third species has been within a short time conclusively demonstrated by Prof. Agassiz, and the evidence on which this conclusion rests will soon be published in a memoir on those genera of Cetaceans whose remains have been found in the United States.

In the Proceedings of the Boston Society of Natural History, vol. ii, p. 198, is a notice by Dr. George A. Perkins of an animal captured in the Cavalla River, W. Africa, known to the natives as Ne-hoo-le, and which Dr. Perkins referred to the genus Manatus. In a note to that communication I stated, that this animal differed from all known species of Manatee, both in the *number of the teeth* which was for the molars $\frac{9}{9}\ \frac{9}{9}$, and in *the absence of nails on the paddles*, as well as in other characters of subordinate value. In the sequel it will be seen however that the formula for the teeth was not correctly stated. The provisional name of *Manatus nasutus* was given to this supposed species.

Quite recently, Dr. Perkins, on his return from Cape Palmas, brought with him and presented to the Boston Society of Natural History, an imperfect cranium of the same species, the lower jaw, the intermaxillary, nasal and temporal bones having been broken off by the natives as they divided the carcass amongst themselves for food. A sufficient number of characteristic parts, however, remain to demonstrate that the species, as formerly suspected, is a new one. In establishing the following characters, the cranium in question has been compared with that of the *Manatus senegalensis, M Americanus and M. latirostris:* the first belonging to the Boston Society of Natural History and the others to the Academy of Natural Sciences of Philadelphia.

I. *Teeth.—Molars* $\frac{10}{10}\ \frac{10}{10}$; the first and second of the series have been dropped and their alveoli are partly filled up; the five following ones on each side, remain in use, but the last three still remain in their alveolar cavities, the roots not having as yet been developed. The enamel on all the teeth, on those which are retained in their sockets as well as on those which are in use, is perfectly smooth. The internal root of each molar has a distinct groove on its inner surface and all the roots are quite divergent. The transverse diameters of the anterior and posterior ridges are more nearly equal than in the other species.

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[*] On a species of Lamantin resembling the M. senegalensis, (Cuvier,) inhabiting the coast of E. Florida. By Richard Harlan, M.D. Journal Acad. Nat. Sciences, Philadelphia. Vol. iii, p. 390.

[†] Osteographie, Fascic. xv. Genus Manatus, p. 123.

M. Senegalensis.—Molars $\frac{8}{8}\,\frac{8}{8}$; the enamel is rugous; the inner root is not grooved, all of the roots nearly vertical, and the teeth in use not more than four. *M. latirostris.* Molars $\frac{10}{10}\,\frac{10}{10}$, teeth in use four or five; enamel rugous. *M. Americanus,* Molars $\frac{11}{11}\,\frac{11}{11}$. Teeth much smaller than in the preceding species; the number in action six. The crowns are higher, but the inner root as in M. nasutus is grooved on its internal surface.

II. *Palate.*—The median ridge is flattened on its summit and the palatine foramina are of variable sizes; the most anterior is the largest and perforates the bone nearly vertically and with rounded edges. In the *M. latirostris* they are all more minute; in the *M. Senegalensis* and *M. Americanus*, the anterior are the largest, but perforate the bone obliquely and are protected for some distance after they assume the horizontal direction by a thin sharp edge or shelf of bone. The palatine foramina are subject to so great variety in most animals, that the characters just enumerated must be regarded as of doubtful value unless verified on a large number of crania.

III. *Malar bones.*—These are readily distinguished from the corresponding bones of all the other species in being very broad in their zygomatic portion, measuring nearly an inch in breadth at their free extremity. In *M. Senegalensis*, the zygomatic portion is slender, style-shaped, and terminated by a knob. This is also the case in *M. Americanus* and *latirostris*, except that in the last the part in question has no enlargement at its end, is a little broader than in the preceding, but forms a much closer union with the zygomatic portion of the temporal bone, approaching a suture of the kind called "harmonia."

IV. *Frontal region.*—In this as well as in *M. Americanus* the frontal region is quite narrow, but in the latter it is rounded, "bombée," while in the former it is depressed. The forehead of the *M. latirostris* and *Senegalensis* is proportionally much broader.

V. *Occipital foramen.*—In all the species this foramen is more or less triangular, the angles being rounded; but in *M. Americanus*, *Senegalensis*, and *latirostris* the apex is directed downwards, while in that from the Cavalla river it is directed upwards.

The number of known species of the genus Manatus now amounts to four, two from Africa, viz.: *M. Senegalensis and M. nasutus*, and two from the New World, viz.: *M. Americanus and M. latirostris.*

ART. X.—*On Denudation in the Pacific;* by JAMES D. DANA.

THE following pages are extracted from different chapters in the Geological Report of the Exploring Expedition under Capt. Wilkes.*

The valleys of the Pacific Islands have usually a course from the interior of the island towards the shores; or when the island consists of two or more distinct summits or heights (like Maui) they extend nearly radiately from the centre of each division of the island. They are of three kinds:

I. A narrow gorge, with barely a pathway for a streamlet at bottom, the enclosing sides diverging upward at an angle of thirty to sixty degrees. Such valleys have a rapid descent, and are bounded by declivities from one hundred to two thousand feet or more in elevation, which are covered with vegetation, though striped nearly horizontally by parallel lines of black rock. There are frequent cascades along their course; and at head, they often abut against the sides of the central inaccessible heights of the island. The streamlet has frequently its source in one or more thready cascades that make an unbroken descent of one or two thousand feet down the precipitous yet verdant walls of the amphitheatre around.

II. A narrow gorge, having the walls vertical or nearly so, and a flat strip of land at bottom more or less uneven, with a streamlet sporting along, first on this side, and then on that, now in rapids, and now with smoother and deeper waters. The walls may be from one hundred to one thousand feet or more in height; they are richly overgrown, yet the rocks are often exposed, though every where more than half concealed by the green drapery.

These gorges vary in character according to their position on the island. Where they cut through the lower plains, (as the dividing plain of Oahu,) they are deep channels with a somewhat even character to the nearly vertical walls, and an open riband of land at bottom. The depth is from one to three hundred feet, and the breadth as many yards. Farther towards the interior, where the mountain slopes and vegetation have begun, the walls are deeply fluted or furrowed, the verdure is more varied and abundant, and cascades are numerous.

This second kind of gorge, still farther towards the interior, changes in character, and becomes a gorge of the first kind, narrowing at bottom to a torrent's course, along which are occasional precipices which only a torrent could descend.

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* U. S. Exploring Expedition during the years 1838–1842, under the command of C. WILKES, U. S. N.—Geology by JAMES D. DANA, A.M., Geologist of the Expedition. 750 pp. 4to, with a folio Atlas of 21 plates of fossils. Philadelphia: 1849.

III. Valleys of the *third* kind have an extensive plain at bottom quite unlike the strip of land just described. They sometimes abut at head against vertical walls, but oftener terminate in a wide break in the mountains.

The ridges of land which intervene between the valleys, have a flat or barely undulated surface, where these valleys intersect the lower plains or slopes; but in the mountains, they are narrow at top, and sometimes scarcely passable along their knife-edge summits. Some of them as they extend inward, become more and more narrow, and terminate in a thin wall, which runs up to the central peaks. Others stop short of these central peaks, and the valleys either side consequently coalesce at their head, or are separated only by a low wall, into which the before lofty ridge had dwindled. The crest is often jagged, or rises in sharp serratures.

The main valleys, which we have more particularly alluded to above, have their subordinate branches; and so the ridges in necessary correspondence, have their subordinate spurs.

As examples of the valleys and ridges here described, we introduce a brief account of an excursion in the Hanapepe valley on Kauai, one of the Hawaiian Islands, and a second up the mountains of Tahiti.

Hanapepe Valley, Kauai.—We reached its enclosing walls, about four miles from the sea, where the sloping plain of the coast was just losing its smooth, undulating surface, and changing into the broken and wooded declivities of the interior. The valley, which had been a channel through the grassy plain, a few hundred feet in depth, was becoming a narrow defile through the mountains. A strip of land lay below, between the rocky walls, covered with deep-green garden-like patches of taro, through which a small stream was hastening on to the sea.

We found a place of descent, and three hundred feet down, reached the banks of the stream, along which we pursued our course. The mountains, as we proceeded, closed rapidly upon us, and we were soon in a narrow gorge, between walls one thousand feet in height, and with a mere line of sky over head. The stream dashed along by us, now on this side of the green strip of land, and then on that; occasionally compelling us to climb up, and cling among the crevices of the walls to avoid its waters, where too deep or rapid to be conveniently forded. Its bed was often rocky, but there was no slope of debris at the base of the walls on either side, and for the greater part of the distance it was bordered by plantations of taro. The style of mountain architecture, observed on the island of Oahu, was exhibited in this shaded defile on a still grander scale. The mural surfaces enclosing it had been wrought, in some places, into a series of semicircular alcoves or recesses, which extended to the distant summits over head: more commonly, the walls were formed of a series of semicircular columns of vast size, collected together like the clustered shafts of a Gothic structure, and terminating several hundred feet above, in low conical summits. Although the sides were erect or nearly so, there was a profuse decoration of vines and flowers, ferns, and shrubbery; and where more inclined, forests covered densely the slopes.

These peculiar architectural features proceed from the wear of rills of waters, streaming down the bold sides of the gorge; they channel the surface, leaving the intermediate parts prominent. The rock is uniformly stratified, and the layers consist of gray basalt or basaltic lava, alternating with basaltic conglomerate.

Cascades were frequently met with; at one place, a dozen were playing around us at the same time, pouring down the high walls, appearing and disappearing, at intervals, amid the foliage, some in white foamy threads, and others in parted strands imperfectly concealing the black surface of rock beneath.

A rough ramble of four miles brought us to the *falls* of the Hanapepe. The precipice, sweeping around with a curve, abruptly closed the defile, and all farther progress was therefore intercepted. We were in an amphitheatre of surpassing grandeur, to which the long defile, with its fluted or Gothic walls, decorated with leaves and flowers and living cascades, seemed a fit porch or entrance-way. The sides around were lofty, and the profuse vegetation was almost as varied in its tints of green as in its forms. On the left stood apart from the walls an inclined columnar peak or leaning tower, overhanging the valley. Its abrupt sides were bare, excepting some tufts of ferns and mosses, while the top was crowned with a clump of bushes. To complete the decorations of the place,—from a gorge on the right, in the verdant mountains above, where the basaltic rocks stood out in curved ascending columns on either side, as if about to meet in a Gothic arch, a stream leaped the precipice and fell in dripping foam to the depths below; where, gathering its strength again, it went on its shaded way down the gorge.

The *mountains of Tahiti* commence their slopes from the sea or a narrow sea-shore plain, and gradually rise on all sides towards the central peaks, the ridges of the north and west terminating in the towering summits of Orohena and Aorai, while the eastern and southern, though reaching towards the same peaks, are partly intercepted by the valley of Papenoo. Aorai is seven thousand feet in height and Orohena not less than eight thousand feet.

We commenced the ascent of Mount Aorai by the ridge on the west side of the Matavai Valley, and, by the skillfulness of our guide, were generally, able to keep the elevated parts of the ridge without descending into the deep valleys which bordered our path. An occasional descent, and a climb on the opposite side of the valley were undertaken; and although the sides were nearly perpendicular, it was accomplished, without much difficulty, by clinging from tree to tree, with the assistance of ropes, at times, where the mural front was otherwise impassable. By noon of the second day, we had reached an elevation of five thousand feet and stood on an area twelve feet square, the summit of an isolated crest in the ridge on which we were travelling. To the east, we looked down two thousand feet into the Matavai Valley; to the west a thousand feet into a branch of the Papaua Valley, the slopes either way, being from sixty to eighty degrees, or within thirty degrees of perpendicular. On the side of our ascent, and beyond, on the opposite side, our peak was united with the adjoining summit by a thin ridge, reached by a steep descent of three hundred feet. This ridge was described, by our natives, as no wider at top than a man's arm, and a fog coming on, they refused to attempt it that day. The next morning being clear, we pursued our course. For a hundred rods, the ridge on which we walked was two to four feet wide, and from it, we looked down, on either side a thousand feet or more, of almost perpendicular descent. Beyond this the ridge continued narrow, though less dangerous, until we approached the high peak of Aorai. This peak had appeared to be conical and equally accessible on different sides, but it proved to have but one place of approach, and that along a wall with precipices of two to three thousand feet, and seldom exceeding two feet in width at top. In one place we sat on it as on the back of a horse, for it was no wider, and pushed ourselves along till we reached a spot where its width was doubled to two feet, and numerous bushes again affording us some security, we dared to walk erect. We at last stood perched on the summit edge, not six feet broad. The ridge continued beyond for a short distance, with the same sharp, knife-edge character, and was then broken off by the Punaavia Valley. Our height afforded a near view of Orohena; it was separated from us only by the Valley of Matavai, from whose profound depths it rose with nearly erect sides. The peak has a saddle shape, and the northern of the two points is called Pitohiti. These summits, and the ridge which stretches from them toward Matavai, intercept the view to the southward. In other directions, the rapid succession of gorge and ridge that characterizes Tahitian scenery, was open before us. At the western foot of Aorai, appeared the Crown. Beyond it extended the Punaavia Valley, the only level spot in sight; and far away, in the same direction, steep ridges, rising behind one another with jagged outline, stood against the western horizon. To the north, deep valleys gorge the country, with narrow precipitous ridges between; and these melt away into ridgy hills and valleys, and finally into the palm-covered plains bordering the sea.

On our descent, we followed the western side of the Papaua Valley, along a narrow ridge such as we have described, but two or three feet wide at top, and enclosed by precipices of not less than a thousand feet. Proceeding thus for two hours, holding to the bushes which served as a kind of balustrade, though occasionally startled by a slip of the foot one side or the other—our path suddenly narrowed to a mere edge of naked rock, and, moreover, the ridge was inclined a little to the east, like a tottering wall. Taking the upper side of the sloping wall, and trusting our feet to the bushes while clinging to the rocks above, carefully dividing our weight lest we should precipitate the rocks and ourselves to the depths below, we continued on till we came to an abrupt break in the ridge of twenty feet, half of which was perpendicular. By means of ropes doubled around the rocks above, we in turn let ourselves down, and soon reached again a width of three feet, where we could walk in safety. Two hours more at last brought us to slopes and ridges where we could breathe freely.

The peculiarities here described characterize all parts of the island. Towards the high peaks of the interior, the ridges which radiate from, or connect with them, become mere mountain walls with inaccessible slopes, and the valleys are from one to three thousand feet in depth. The central peaks themselves have the same wall-like character. It is thus with Orohena and Pitohiti, as well as Aorai; and owing to the sharpness of the summit edge, rather than the steepness of the ascent, Orohena is said to be quite inaccessible. Dr. Pickering and Mr. Couthouy, in an excursion to a height of five thousand feet on this ridge, met with difficulties of the same character we have described.

Without citing other examples, we continue with the author's remarks on the origin of these valleys.

The causes operating in the Pacific, which may have contributed to valley-making, are the following:

1. Convulsions from internal forces, or volcanic action.
2. Degradation from the action of the sea.
3. Gradual wear from running water derived from the rains.
4. Gradual decomposition through the agency of the elements and growing vegetation.

The *action of volcanic forces* in the formation of valleys, is finely illustrated in the great rupture in the summit of Hale-a-kala on Maui. The two valleys formed by the eruption are as extensive as any in the Hawaiian Group. being two thousand feet deep at their highest part, and one to two miles wide. They extend from the interior outward towards the sea. Above, they open into a common amphitheatre, the remains of the former crater, the walls of which are two thousand feet high.

As other examples of volcanic action, we may refer to the pit craters of Mount Loa, among which Kilauea stands preëminent. This great corral, if we may use a Madeira word, is a thousand feet deep, one to two miles wide, and over three long, so that it forms a cavity which may compare advantageously with many valleys; and were the walls on one side removed, it might become the head of a valley like that of Hale-a-kala on Maui.

As an example of this kind of valley upon islands which have lost their original volcanic form, we venture to refer to the wide Nuuanu, back of Honolulu, (island of Oahu,) which has at its head on either side, a peak rising above it to a height of two thousand four hundred feet, or four thousand feet above the sea.

The immense amphitheatre to the west of the lofty Orohena and Aorai, on the island of Tahiti, is remarkable for its great breadth, and the towering summits which overhang it; and if not a parallel case to that of Maui, that is, if the head was not originally the great crater, there must have been a subsidence or removal of a large tract by internal forces.

The precipice of the eastern mountain of Oahu, is another example of the effect of convulsion in altering the features of islands, causing either a removal or subsidence.

The many fissures which are opened by the action of Kilauea, might be looked upon as valleys on a smaller scale, and the germs of more extensive ones. But with few exceptions, these fissures as soon as made are closed by the ejected lava, and the mountain is here no weaker than before. Those which remain open, may be the means of determining the direction of valleys afterwards formed.

Action of the sea.—The action of the sea in valley-making, is supposed to have been exerted during the rise of the land; and as such changes of level have taken place in the Pacific, this cause it would seem, must have had as extensive operation in this vast ocean as any where in the world, especially as the lands are small and encircled by the sea, and there is, therefore, a large amount of coast exposed, in proportion to the whole area.

But in order to apprehend the full effect of this mode of degradation, we should refer to its action on existing shores.* At the outset we are surprised at finding little evidence of any such action now in progress along lines of coast. The islands, and the shores of continents have occasional bays, but none that are deepening by the action of the sea. The waves tend rather to fill up the bays and remove by degradation the prominent capes, thus rendering the coast more even, and at the same time, accumulating beaches that protect it from wear. If this is the case on shores where there are deep bays, what should it be on submarine slopes successively becoming the shores, in which the surface is quite even compared with the present outline of the islands? Instead of making bays and channels, it can only give greater regularity to the line of coast.

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* The view here presented is sustained in De la Beche's Geological Researches, page 192.

Upon the North American coast, from Long Island to Florida there are no valleys in progress from the action of the sea. On the contrary, we ascertain by soundings that the bottom is singularly even; and the bays, as that of New York, are so acted upon by the sea, that were it not, in the case mentioned, for the action of the current of the Hudson River, its limits would continue gradually to contract. Around Tahiti there are no submarine valleys. The valleys of the land are often two thousand feet deep; but they die out towards the shores. Thus over the world, scarcely an instance can be pointed out of valley making from the action of the sea. During the slow rise of a country, the condition would not be more favorable for this effect than in a time of perfect quiet. If America were to be elevated, would the action make valleys in the shores just referred to? If England were slowly to rise, would this favor the scooping of valleys through its beaches? Would not beach formations continue to be the legitimate production of the sea along its line of wave action; and where the rocks should favor the opening of a deep cove, would not the same action go on as now, causing a wear of the headlands and a filling up of the cove at its head? Were Tahiti now to continue rising, could the waves make valleys on the coast? The increasing height of the mountains would give the streams of the land greater eroding force, and more copious waters; but the levelling waves would continue to act as at the present time. The effects of the sea in making valleys have been much exaggerated, as is obvious from this appeal to existing operations, the appropriate test of truth in geology.

The action of a rush of waters in a few great waves over the land, such as might attend a convulsive elevation, though generally having a levelling effect, might produce some excavations, as is readily conceived; yet it is obvious on a moment's consideration, that such waves could not make the deep valleys, miles in length, that intersect the rocks and mountains of our globe.

But it is supposed that there may be fissures about volcanic islands in which the sea could ply its force. Yet even in these cases, unless the fissures were large, the seashore accumulations would be most likely to fill and obstruct them. To try this hypothesis by facts, we remark that there are no such shore fissures around Mount Loa, nor any of the other Hawaiian Islands. The fissures formed by volcanic action immediately about a volcano, are generally filled at once with lavas as we have stated, and the vent is mended by the force which made it. It is, therefore, a gratuitous assumption that such fissures have been common. The existence, however, of large valleys such as have been attributed above to convulsions cannot be doubted; but the sea would exert its power in such places, nearly as now in Faugaloa Bay, Tutuila, and other bays in continents;—a beach forms, and a shore plain, and afterwards there is a little action from the sea in these confined areas of water.

In the Illawarra district, New South Wales, there are several places where dikes of basalt have been removed by the sea, and channels one hundred yards in depth, of the width of the dike (six feet), now exist, cutting straight into the rocky land. This is an example of the action of the sea where everything is most favorable for it. And we observe that there is little resemblance in this narrow channel with but a trifling wear of the inclosing rocks, to the valleys which are to be accounted for in the Pacific; and little authority to be derived from it for attributing much efficacy to the sea in wearing out valleys. The reason of this is apparent in the fact that the sea rolls up a coast in great swells, and cannot parcel itself off, and act like a set of gouges: this latter effect it leaves for the streams and streamlets of the shores which are gouges of all dimensions.

Although the sea can accomplish little along coasts towards excavating valleys, yet when the land is wholly submerged, or only the mountain summits peer out as islands, the great oceanic currents sweeping over the surface and through channels between the islands, would wear away the rocks or earth beneath. From the breadth and character of such marine sweepings, we learn that the excavations formed would be very broad rounded valleys; and their courses would correspond in some degree with the probable direction which the currents of the ocean would have, over the region in case of a submergence. Moreover where there are different open channels for the ingress of the sea, having free intercommunication, there are often strong currents connected with the tides, and consequently much erosion. It is obvious that the valleys of the Pacific islands have nothing in their features or positions attributable to such a cause.

Running water of the land, and gradual decomposition.—Of the causes of valleys mentioned in the outset we are forced to rely for explanations principally upon running streams: and they are not only gouges of all dimensions, but of great power, and in constant action. There are several classes of facts which support us in this conclusion.

a. We observe that Mount Loa, whose sides are still flooded with lavas at intervals, has but one or two streamlets over all its slopes, and the surface has none of the deep valleys common about other summits. Here volcanic action has had a smoothing effect, and by its continuation to this time, the waters have had scarcely a chance to make a beginning in denudation.

Mount Kea, which has been extinct for a long period, has a succession of valleys on its windward or rainy side, which are several hundred feet deep at the coast and gradually diminish upward, extending in general about half or two-thirds of the way to the summit. But to the westward it has dry declivities, which are comparatively even at base, with little running water. A direct connection is thus evinced between a windward exposure, and the existence of valleys: and we observe also that the time since volcanic action ceased is approximately or relatively indicated, for it has been long enough for the valleys to have advanced only part way to the summit. Degradation from running water would of course commence at the foot of the mountain, where the waters are necessarily more abundant and more powerful in denuding action, in consequence of their gradual accumulation on their descent. Mount Kea, like Mount Loa, is nearly 14,000 feet high, and the average slope is 7 to 8 degrees.

Hale-a-kala on Maui offers the same facts as Mount Kea, indicating the same relation between the features of the surface and the climate of the different sides of the island. On Eastern Oahu the valleys are still more extensive; yet the slopes of the original mountains may be in part distinguished. And thus we are gradually led to Kauai, the westernmost of the Hawaiian Islands, where the valleys are very profound and the former slopes can hardly be made out. The facts are so progressive in character, that we must attribute all equally to the running waters of the land.

The valleys of Mount Kea alone, extending some thousands of feet up its sides, sustain us in saying, that time only is required for the formation of similar valleys elsewhere in the Pacific. As in Tahiti, so in other islands. these valleys take the direction of the former slopes; and though they may be of great depth and commence even under the central summits, they *terminate at the sea level, instead of continuing beneath it.*

The fluting of the walls of the Hanapepe Valley, a thousand feet or more in height, has been described on a preceding page. It cannot be doubted here that water was the agent; for the rills are seen at work. The contrast between the same valley near the sea, and in the mountains, (the walls in the former case being nearly unworn vertically,) is explained on the same principle: for the mountains are a region of frequent rains and almost constant clouds, and therefore abound in streams and streamlets and threads of water; while below, there are grassy plains instead of forest declivities, and but little rain. These furrowings vary from a few yards in width and depth to many furlongs.

The long and lofty precipice of Eastern Oahu, is an excellent place for studying farther this action. It is fluted in the same style as the Hanapepe Valley. In the distant view the vertical channels appear very narrow; but when closely examined they are found to be deep and often winding passages. The precipice faces to the windward, and is directly under the whole line of peaks in the mountain range, both of which facts account for an abundance of water. Going to the westward along the range, the precipice changes to a sloping declivity, and these passages become deeper and longer, and more winding, just in proportion to the increasing length of the slopes: moreover at the same time they decrease in number. Where there is no slope to collect the waters, the rills act independently, and their furrowings like themselves are small, narrow, and numerous; but as the declivity becomes gradual, the rills flow on and collect into larger streams, and the furrowings become deeper and more distant. Over this region, no distinction can be drawn as regards origin between these flutings and the gorges: and in respect to features, only this difference appears, that the size of the excavations is less and the number greater, the steeper the declivity. If a fissure be appealed to as the commencement of the longer valleys, it should also be admitted for each of the flutings. But this idea is wholly inadmissible.

A brief review of the action of flowing waters with reference to the different results described may place this subject in a clear light.

a. Suppose a mountain, sloping around like one of the volcanic domes of the Pacific.—The excavating power at work proceeds from the rains or condensed vapor, and depends upon the amount of water and rapidity of slope.

b. The transporting force of flowing water* increases as the sixth power of the velocity,—double the velocity giving sixty-four times the transporting power.—The eroding force will be greater than this on a mountain declivity, where the waters add their own gravity to the direct action of a progressive movement.

c. Hence, if the slopes are steep, the water gathering into rills excavates so rapidly, that every growing streamlet ploughs out a gorge or furrow; and consequently the number of separate gorges is very large, and their sizes comparatively small, though of great depth.

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* It has been shown by W. Hopkins, Esq., that the moving force of running water, (this force being estimated by the volume or weight of a mass of any given form which it is just capable of moving,) varies as the *sixth* power of the velocity. He says, "if a stream of ten miles an hour would just move a block of five tons weight, a current of fifteen miles an hour would move a block of similar form upwards of fifty-five tons; a current of twenty miles an hour would, according to the same law, move a block of three hundred and twenty tons: again, according to the same law, a current of two miles an hour would move a pebble of similar form of only a few ounces in weight."—*On the Transport of Erratic Blocks*, Trans. Camb. Phil. Soc., 1844, viii, 221, 233.

d. But if the slopes are gradual, the rills flow into one another from a broad area, and enlarge a central trunk, which continues on towards the sea, with frequent additions from either side. The excavation above, for a while, is small; for the greater abundance of water below, during the rainy seasons, causes the denudation to be greatest there, and in this part the gorge or valley most rapidly forms. In its progress, it enlarges from below upward, though also increasing above; at the same time, the many tributaries are making lateral branches.

e. Towards the foot of the mountain, the excavating power ceases whenever the stream has no longer in this part a rapid descent,—that is whenever the slope is not above one or two feet to the mile. The stream *then consists of two parts, the torrent of the mountains and the slower waters below*, and the latter is gradually lengthening at the expense of the former.

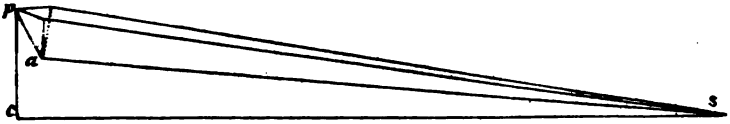
f. After the lower waters have nearly ceased excavation, a new process commences in this part,—that of widening the valley. The stream which here effects little change at low water, is flooded in certain seasons, and the abundant waters act *laterally* against the enclosing rocks. Gradually, through this undermining and denuding operation, the *narrow bed becomes a flat strip of land, between lofty precipices*, through which, in the rainy season, the streamlet flows in a winding course. The streamlet, as the flat bottom of the valley is made, deposits detritus on its banks, which in some places so accumulates as to prevent an overflow of the banks by any ordinary freshet. Such is the origin of the deep channels with a riband of land at bottom that cut through the "dividing plain" of Oahu, and which are common towards the shores of many of the Pacific islands.

g. The torrent part of the stream, as it goes on excavating, is gradually becoming more and more steep. The rock-material operated upon, consists of layers of unequal hardness, varying but little from horizontality and dipping towards the sea, and this occasions the formation of cascades. Whenever a softer layer wears more rapidly than one above, it causes an abrupt fall in the stream: it may be at first but a few feet in height; but the process begun, it goes on with accumulating power. The descending waters in this spot add their whole weight, as well as a greatly increased velocity, to their ordinary force, and the excavation below goes on rapidly, removing even the harder layers. The consequences are, a fall of increasing height, and a basin-like excavation directly beneath the fall. Often, for a short distance below, the stream moves quietly before rushing again on its torrent course, and when this result is attained by the action, the height of the fall has nearly reached its limit as far as excavation below is concerned;—though it may continue to increase from the gradual wear and removal of the rocks over which it descends.

h. As the gorge increases in steepness, the excavations above deepen rapidly,—the more rapid descent more than compensating, it may be, for any difference in the amount of water. Moreover, as the rains are generally most frequent at the very summits, the rills in this part are kept in almost constant action through the year, while a few miles nearer the sea they are often dried up or absorbed among the cavernous rocks. The denudation is consequently at all times great about the higher parts of the gorge, (especially after the slopes have become steep by previous degradation;) thus finally a steep precipice forms the head of the valley.

i. The waters descending the ridges either side of the valley or gorge, are also removing these barriers between adjacent valleys, and are producing as a *first* effect, a thinning of the ridge at summit to a mere edge; and as a *second*, its partial or entire removal, so that the two valleys may at last be separated only by a low wall, or even terminate in a common head,—a wide amphitheatre enclosed by the lofty mountains. In one case, the ridge between the two valleys, which towards the shores of the island has rather a broad back, high up in the region of mists and frequent rains becomes a narrow wall, and thus connects with the central summit. In the second, the ridge finally terminates abruptly, and a deep valley separates it from the main mountain.

The following sketch may assist the mind in conceiving of the action upon the Pacific mountains. It represents one of the valleys of Tahiti from the centre to the shore, excepting its irregularities of direction and descent, and the uneven character of its walls, arising from lateral valleys and minor denudations. The height of Tahiti is about eight thousand feet; its radius *c s* is ten geographical miles. The head of the valley at *a* is three thousand feet below the summit peak *p*. The descent along the air-line from *a* to *s*, averages five hundred feet to the mile. If *a* be four thousand feet below the summit, (the exact depth was not ascertained,) it would still give four hundred feet to the mile.



This subject is beautifully illustrated in some of the tufa cones of Oahu, where, on a smaller scale, we have the same kind of gorge and valley; and in this case, there is no doubt that denudation was the cause by which they were produced. The valleys have the direction of the slopes, and are similar in form and winding character to those of the mountains. The intervening ridges are also similar. Many of them become very thin at summit as they rise towards the crest of the volcanic cone, and others have this upper part adjoining the crest wanting, owing to the extent of the degradation, so that two valleys have a common head against the vertical bluff. A better model of the mountain gorges could hardly be made, and it stands near by, convenient for comparison. Diamond Hill, one of these cones, is 800 feet high.

We need add little, in this place, on the capabilities of running water, after the statement, based on mathematics, that the transporting force varies as the sixth power of the velocity. If we remember that these mountain streams at times increase their violence a million fold when the rains swell the waters to a flood, all incredibility on this point must be removed.

A few thousand feet in depth, even in the solid rocks, is no great affair for an agent of such ceaseless activity, during the periods which have elapsed since the lands became exposed to their influence. And when we take into view the lofty heights of the Pacific islands, their rapid declivities giving speed to the waters and transported stones and earth, we must admit that of all lands, these are especially fitted for denudation by torrents.

The nature of the rocks also favors wear and removal. They are in successive layers, soft conglomerates or tufas frequently alternating with the harder basalt or basaltic lava. Moreover, the rock is commonly much fissured, owing to a tendency to a columnar structure; besides, they are often cellular. The waters thus find admission, promoting decomposition and also degradation. There are, also, frequent caverns between layers, which contribute to the same end.

There is every thing favorable for degradation which can exist in a land of perpetual summer: and there is a full balance against the frosts of colder regions in the exuberance of vegetable life, since it occasions rapid decomposition of the surface, covering even the face of a precipice with a thick layer of altered rock, and with spots of soil wherever there is a chink or shelf for its lodgment. The traveler on one of these islands ascending a valley on a summer day, when the streams are reduced to a mere creeping rill which half the time burrows out of sight, seeing the rich foliage around, vines and flowers in profusion covering the declivities and festooning the trees, and observing scarcely a bare rock or stone excepting a few it may be along the bottom of the gorge, might naturally inquire with some degree of wonder, where are the mighty agents which have channeled the lofty mountains to their base? But though silent, the agents are still on every side at work; decomposition is in slow, but constant progress; the percolating waters are acting internally, if not at the surface. Moreover, at another season, he would find the scene changed to one of noisy waters, careering along over rocks and plunging down heights with frightful velocity; and then the power of the stream would not be disputed.*

But if the waters have been thus efficient in causing denudation and opening valleys, may not fissures or dikes have determined their courses? The only test of truth, an appeal to facts, may answer the question. Mount Loa is a mountain yet unchanged. It has its dikes in great numbers: but over these dikes the country is more apt to be *raised* a little from the overflow of lavas than depressed, and this would turn off the water. Again, we see no instances of dikes yielding, and offering a course for a stream. As to unfilled fissures, there are few of them, and these, with rare exceptions, are immediately about the active vents. Is either supposition then sustained by the facts presented? We know the tendency of water to take the lowest parts of a surface, and will it not follow these parts, whether or not there be a dike or fissure? It is obvious that whatever ravines or depressions the floods of lava may have left, would be the courses of the waters; and these depressions would be followed to the sea, and ultimately become valleys. We may believe that the waters would not wait till there was a convenient fissure; they would go where *inclination* led, and make valleys with little difficulty, if there were no guiding or aiding fissures. Were the dikes filled by a rock more decomposable or more easily eroded than those enclosing it, as is the case in some granitic regions, we should expect that they would frequently become water courses: but this is seldom the fact in the Pacific islands.

The valleys in some of the Canary Islands, extend from the shores part way to the summit, as on Mount Kea and Hale-a-kala, and evidently for the reason already explained. We can detect in regions of a similar kind, no evidence that the valleys have depended for their origin on the mountain's being a "crater of elevation," as von Buch urges.* The regular stratification of the sides of these valleys; the absence of all tiltings; their situation, as related to the rains; and the absence of fissures ready for making valleys on the leeward declivities, are points which favor no such theory: and, moreover, it is an unnecessary hypothesis.

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* The rise of the streams, from the rains of the mountains, is often so rapid that in some instances, the native villages of the coast become flooded, before they have time even to move their property.—*Miss. Herald*, xxiii, 207.

Mr. Coan, who has often traversed the coast of Hawaii, north of Hilo, and during the drier seasons, (which, however, are of short duration on this, the windward coast,) fords the shallow streams without difficulty, gives the following account of his journey during a time of rains. "Great and continued rains fell during my absence, and the numerous rivers became so swollen and furious that the very sight of them was fearful. These raging streams crossed my path about *once in half a mile* for a distance of about thirty miles, and I was compelled to cross them to return home. Most of them run at a rate of twenty or thirty miles an hour, and in their course there are numerous cataracts from ten to a hundred and fifty feet in perpendicular descent. Though the torrents were so fearful as to make one almost quail at the thought of struggling with their fury, ropes were provided, and several men employed for the adventurous task. Great calmness and presence of mind, and great energy and muscular effort, were required to retain one's grasp of the rope, and buffet with the foaming flood. We at last succeeded, though at imminent peril. At one of the rivers, we spent three hours in finding a place where we might, with any degree of safety, extend our hawser across, and transfer our party to the opposite bank. The streams are at the bottom of narrow ravines, with the banks exceedingly precipitous, and often perpendicular bluffs of basaltic rock."—*Miss. Herald*, xxxviii, 157.

We are thus led to conclude that between convulsions from subterranean forces, and degradation from waters supplied by the rains and attending decomposition, a lofty volcanic dome may be changed to a skeleton island like Tahiti. We have referred to Mount Loa as still unfurrowed; to Mount Kea and Hale-a-kala as having only the lower slopes deeply channeled with narrow gorges; and to other islands, as exemplifying all gradations in these effects to those in which the original features are no longer to be traced: we have pointed out the difference in the windward and leeward slopes, and have shown a relation between the quantity of rain and the amount of degradation:—we have exhibited a model of the mountains, an undeniable result of denudation, placed at their very base, as if for illustration:—and thus we have traced out and elucidated all the steps in the valley-making process, and have also shown them to be a necessary result from the action of running water.

Again, examples of convulsions from igneous forces have been pointed out in the great gorges of Hale-a-kala, and in Kilauea and other Hawaiian craters; in the mountain wall of Oahu, and similar scenes on other islands; in the wide amphitheatre of central Tahiti: and the importance of this means of change has thus been exhibited. Yet few such changes are apparent on any one island, and these are marked by decided characters not often to be mistaken. It has also been shown that although fissures made by volcanic forces, may in some cases have given the direction to valleys, yet they are by no means necessary in order that valleys should commence to form.

With literal truth may we speak of the valleys of the Pacific Islands, as the furrowings of time, and read in them marks of age. Our former conclusion with regard to the different periods which have passed over the several Hawaiian Islands since the fires ceased and wear begun, is fully substantiated. We also learn how completely the features of an island may be obliterated by this simple process, and even a cluster of peaks like Orohena, Pitohiti and Aorai of Tahiti, be derived from a simple volcanic dome or cone. Mount Loa, alone, contains within itself the material from which an island like Tahiti might be modeled, that should have near twice its height and four times its geographical extent.

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* See Iles Canaries, p. 285.

ART. XI.—*Remarks on the Constitution of Leucine, with critical observations upon the late Researches of M. Wutz;* by T. S. HUNT.

IN the American Journal for January, 1848, p. 123, I made some suggestions as to the true composition of leucine and proposed a correction of the formula which had been deduced by M. Mulder from his analyses. After noticing the sulphuretted alkaloid thialdine, lately discovered by Wöhler and Liebig, I remarked that it corresponded to a normal species whose formula is $C_{12}H_{13}NO_4$, which would be a homologue of glycocoll, "and very probably no other than leucine." This correction I ventured upon without having before me the analytical results of M. Mulder, because as I have stated, the formula deduced by that chemist, $C_{12}H_{12}NO_4$, was irreconcilable with the law which MM. Gerhardt and Laurent have announced as governing the composition of all azotized bodies. My proposed formula on the contrary, made this anomaly to disappear, and showing it a homologue of glycocoll, a substance formed at the same time with it, by the action of potash upon gelatine, at once explained the singular reactions of leucine with nitric acid, already described by M. Braconnot. Not having it in my power to verify any farther my view, I left the matter to the consideration of chemists.

In the Comptes Rendus de l'Acad. for Sept. 4th, 1848, there appears a communication from M. Cahours, who had submitted to analysis both leucine and aposepedine, (a product of the putrefaction of caseine which Mulder had supposed to be identical with leucine,) and found the two substances to agree in composition and to have precisely the formula which I had previously assigned. He has found that they form beautifully crystalline compounds with nitric and hydrochloric acids, and gives to the former the formula $C_{12}H_{13}NO_4$, NO_5 HO. M. Cahours has also pointed out the relation between this body and thialdine and their homology with glycocoll. The *surcosine* obtained by M. Liebig, by the action of barytic water upon creatine, has the formula $C_6H_7NO_4$ and belongs to the same homologous series.

The Annales de Chimie et de Physique for Nov., 1848, contains a memoir on the same subject by MM. Laurent and Gerhardt, from which it appears, that led by the same considerations as M. Cahours and myself, they have submitted leucine and its compound with nitric acid to analysis, and have arrived at the same conclusions as to its composition and homologous relations. None of these gentlemen however have alluded to my observations published ten months previous, which appear to have escaped their notice.

My formula requires C 54·9, H 9·9, N 10·7, O 24·5. The analyses of Mulder show on comparison with this, a little deficiency in the H and N, but those of M. Cahours are very close approximations. He obtained the following numbers:

	Aposepedine.			Leucine.	
Carbon, . .	55·19	55·04	54·86	55·12	54·79
Hydrogen, . .	9·86	10·11	10·06	10·06	10·04
Azote, . . .	10·63	10·85	10·89	10·89	

The first analyses of MM. Laurent and Gerhardt made upon aposepedine, showed a deficiency in the carbon, but by solution in nitric acid and evaporation, the salt already described was obtained in beautiful crystalline needles, which, dried at 212° F., corresponded exactly with the numbers calculated from the formula $C_{12} H_{13} NO_4, NO_5 HO$, or in their notation, $C_6 H_{13} NO_2, NHO_3$. This salt dissolved in a little water, mixed with alcohol, and precipitated while hot by ammonia, gave leucine in fine white scales, entirely inodorous; the analysis of this gave C 54·6, H 9·9. These results establish beyond all doubt the new formula.

The hydrochloric compound gave Cl 20·6, which corresponds to the formula $C_6 H_{13} NO_2, HCl$. The nitrate, nitro-leucic acid of M. Bracconnot, forms, as that chemist had shown, crystallizable salts with lime and magnesia, and the authors have described a similar silver-salt. They remark moreover upon the fact that the three known alkaloids of this series appear to be derived from the same parent substance, for the sarcosine has been obtained from creatine which is without doubt a product of the transformation of the muscular tissues, and they suggest that sarcosine and the two homologues yet unknown, between this substance and leucine, may be detected in the products of these transformations of the animal matters, which yield glycocoll and leucine.

M. Laurent in a late memoir,* has shown that glycocoll may be regarded as the amid of an acid which is $C_4 H_4 O_6$, and differs from the acetate only by two equivalents of oxygen. For this acid he proposes the name of *glycocollic;* glycocoll will then be *glycolamic acid.* Mr. Horsford, by the action of chlorine upon a solution of glycocoll, obtained a substance which gave with chlorid of barium a crystallized salt, to which he ascribes the formula $C_3 H_3 O_6$, BaO,† but as M. Gerhardt has remarked, an equivalent of the carbon would be retained by the baryta as a carbonate, and that making a correction for this, the numbers obtained lead to $C_4 H_3 O_5, BaC = C_4 H_3 BaO_6$ which is that of the barytic salt of glycocollic acid.

This new genus is homologous with the carbonates, and sustains the same relation to the acetate, as the carbonic $C_2 H_2 O_6$ does to formic acid. Carbonic acid is the type of a series of acids, including the glycocollic which are bibasic; the glycocolls are then monamids of bibasic acids, and while they possess the power of combining with acids, like alkaloids, have still an atom of saline hydrogen so that they may combine alike with nitric acid and nitrate of silver. The nitrate of glycocoll is indeed a copulate of two monobasic compounds, and thus in accordance with M. Gerhardt's law of saturation necessarily bibasic.

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* Annal. de Chim. et de Phys., May, 1848, p. 111.

† Am. Jour. Sci., Nov., 1847, p. 327

The glycocolls are isomeric with urethane and urethylane, those singular compounds discovered by M. Dumas by acting with ammonia and upon the chlorocarbonic ethers of ethylic and methylic alcohol.

Glycocoll is isomeric with urethylane, and sarcosine with urethane; leucine corresponds in the same manner to the unknown uramylane. The late researches of Wurtz upon the cyanic ethers* have made known some other new substances which sustain intimate relations to these bodies. I have shown some time since, that water is to be regarded as the homologue of the alcohols, and that consequently the ethers are homologous with their parent acids,† and M. Wurtz has found that as cyanic acid combines with ammonia and produces urea $C_2H_4N_2O_2$, a body pertaining to the formic series; the cyanic ethers give rise by the same action to two new compounds which have the formulas $C_4H_6N_2O_2$ and $C_6H_8N_2O_2$ and are the ureas of the acetic and metacetic series.

The action of water upon the cyanic ethers is not less remarkable; carbonic acid gas is disengaged and crystalline substances are formed which are soluble in alcohol and water. The reaction is dependent upon the assimilation of the elements of water and is thus represented,

$$2C_4H_3NO_2+2HO=2CO_2+C_6H_8N_2O_2$$
$$2C_6H_5NO_2+2HO=2CO_2+C_{10}H_{12}N_2O_2.$$

The first of these has the composition of metacetic urea, and the second that of valerianic urea, but the substance thus obtained from the cyanomethylic ether differs from the true metacetic urea in its properties, and M. Wurtz hence regards these new bodies as constituting an isomeric group.

We have then in the urethanes and the glycocolls, the ureas and the new compounds of Wurtz, two groups of isomeric bodies which present some interesting relations. If the glycocolls are the monamids of their peculiar acids, the new compounds of Wurtz are equally their binamids.

	Acids.	Glycocolls.	Comps. of Wurtz.	Urethanes.	Ureas.
Formic series,	$C_2H_2O_6$	unknown.	———	———	$C_2H_4N_2O_2$
Acetic "	$C_4H_4O_6$	$C_4H_5NO_4$	unknown.	$C_4H_5NO_4$	$C_4H_6N_2O_2$
Metacetic "	$C_6H_6O_6$	$C_6H_7NO_4$	$C_6H_8N_2O_2$	$C_6H_7NO_4$	$C_6H_8N_2O_2$
Butyric "	$C_8H_8O_6$	unknown.	unknown.	unknown.	unknown.
Valerianic "	$C_{10}H_{10}O_6$	"	$C_{10}H_{12}N_2O_2$	"	"
Caproic "	$C_{13}H_{12}O_6$	$C_{12}H_{13}NO_4$	unknown.	"	"

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* Chem. Gazette, Oct. 16th, from Comptes Rendus, Aug. 28th, 1848.

† This Jour., March, 1848, p. 265.

The farther researches of Wurtz upon the decomposition of the ureas will, I think, enable us to understand more clearly the nature of these bodies. The formic urea, by the action of a solution of potash, is resolved into carbonic acid and two equivalents of ammonia; acetic urea, which differs from it by $C_2 H_2$, is decomposed in a similar manner and yields one equivalent of ammonia and one of a new alkaloid homologous with it, which is represented by $C_2 H_5 N$. The transformation may be thus represented:

Formic urea, $C_2H_4N_2O_2+2KHO_2=C_2K_2O_6+NH_3+NH_3$.

Acetic urea, $C_4H_6N_2O_2+2KHO_2=C_2K_2O_6+NH_3+C_2H_5N$.

In the same way metacetic urea yields $C_4 H_7 N$; these alkaloids sustain to their respective alcohols the same relation that ammonia does to water. The action of potash upon the cyanic ethers has enabled M. Wurtz to obtain two new bodies in a state of purity; for as the ureas consist of these ethers with the addition of NH_3, we can easily see that the decomposition of the latter will give the alkaloids unmixed with ammonia. The discoverer has described them under the names of *methylamid* and *ethylamid*, but *methylamine* and *ethylamine* are more consonant with the nomenclature adopted for the alkaloids. The first is a permanent gas, and the second a very volatile liquid, both having a strong odor of ammonia, powerfully alkaline and caustic; they precipitate metallic solutions, and form with acids, crystallizable salts, which are distinguished by their ready solubility in hot absolute alcohol.* M. Dumas suggests that from their similarity of odor, they may often be mistaken for ammonia, when evolved in organic transformations.

It now becomes important to consider what will be the results of the action of alkalies upon the isomeres of the ureas, and the other bodies which we have placed beside them. M. Wurtz, at the time when he described the first, had not discovered these new alkaloids, and in his subsequent memoir does not appear to have submitted them to experiment. It will probably be found that their decomposition yields ammonia only and not the new alkaloids, and that the difference between metacetic urea and its isomere is that while the latter is the binamid of the acid $C_6 H_6 O_6$, the former (as appears from the results of its decomposition) is the amido-ethylamid of carbonic acid.

The urethanes will probably be found to yield methylamine and ethylamine by the action of potash, but it is otherwise with their isomeres, the glycocolls; Liebig has found that leucine evolves ammonia and hydrogen by the action of hydrate of potash and forms a *valerianite*. Horsford, on the other hand, observed the evolution of ammonia and hydrogen by that agent from glycocoll, and found in the residue an oxalate; its analogy with leucine would lead us to expect formic acid, but Peligot has shown that a formiate when fused with excess of potash, is converted with the evolution of hydrogen into an oxalate, so that the product of Mr. Horsford's experiment was the result of a secondary action.

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* Chem. Gazette, March 15th, from Compt. Rend., Feb. 12th, 1849.

When thus regarded, the isomerism of these two classes of bodies is already explained; it is precisely that which exists between the acetic methylic ether and the formic ethylic ether, two bodies scarcely distinguishable but by the action of an alkali, which converts the one into an acetate and methol, and the other into a formiate and alcohol; the number of these isomeres is only limited by the want of the higher alcohols. It follows then that there does not exist a homologue of urea in the first family, for here in this primitive species the two groups are confounded, and farther it appears, that as we rise in the scale the number of possible isomeres is greatly increased. In the third family we have regarded the compound of Wurtz as the binamid of the acid of that family, while the new urea is an amido-ethylamid of the acid of the first family; there may equally exist a bimethylamid of carbonic acid or an amido-ethylamid of glycocollic acid, all of which will be isomeric with metacetic urea. The discovery of these new alkaloids enables us, by combining the elements (C H) in various ways, to increase the number of homologues and isomeric substances to an extent which is almost inconceivable.

The action of nitrous acid upon urea is well known to result in its conversion into nitrogen and carbonic acid, which is at once decomposed into water and an anhydrid, and a similar process has been adopted by Piria in his beautiful researches upon asparagine; he has demonstrated that in this way many amids are readily decomposed into nitrogen and a non-azotized body.

A similar process applied to glycocoll, sarcosine and leucine, would probably enable us to eliminate the acids of that series,[*] while the decomposition of the urethanes and higher ureas as well as the new alkaloids under its action, still presents a curious subject for investigation.

Montreal, May 22d, 1849.

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[*] M. Cahours has observed in the memoir above quoted, that when leucine is treated with oxydizing agents or exposed to the air in solution, it is decomposed with the evolution of a very disagreeable odor, and the formation of an acid which he supposes may be a homologue of the glycocollic, and he suggests that sarcosine by a similar process may afford the lactic acid. But here he appears to be in error, for the neutral lactates are represented by $C_{12} H_{10} M_2 O_{12}$, ($C_6 H_{10} M_2 O_6$, Gerhardt,) while in the same notation, sarcosine is $C_6 H_7 NO_4$. The lactic is consequently polymeric of the *sarcosic* acid which in M. Gerhardt's notation will be $C_3 H_6 O_3$. Lactic acid has hitherto been described as monobasic, but Engelhardt and Maddsell in their late researches upon its salts, (Liebig's Annal., lxiii, p. 83,) arrive at the conclusion that it is bibasic, apparently ignorant that M. Gerhardt had long before announced the same thing, (Precis, tome 1er, p. 596.)

ART. XII.—*On Perfect Musical Intonation, and the fundamental Laws of Music on which it depends, with remarks showing the practicability of attaining this Perfect Intonation in the Organ;* by HENRY WARD POOLE, Worcester, Massachusetts.

1. THIS paper will treat only of one department of the science of music—the laws which fix the *tune* of all musical scales, and determine all musical intervals. Any one, who is at all conversant with the musical discussions of the last few centuries, will perceive that this is but partly explored and disputed territory, where eminent scientific writers have entertained different opinions, while *all* have agreed in admitting the fact, that there ever have been, and still are, difficulties and imperfections in the musical scale, as executed on organs, piano fortes, &c., which no one has yet shown how to overcome. It is with the belief that he has overcome these difficulties and is able to throw light on this abstruse and unsettled department of the science, in a *practical* point of view, that the writer proposes to discuss it. Very little on this subject reaches the eye of the theoretical and practical musician. In our elementary musical works it is either omitted, or if treated, is not understood; indeed the writer is not aware of a treatise in which it is fully or correctly discussed.

2. It is a singular fact, that while the human ear delights in pure harmony, (as performed by voices, violins and other instruments without *fixed scales*,) and while improvement has been made in every other science and mechanical art, the organ of the present day has all the imperfection of intonation which pertained to that instrument, four centuries since. For so long a period has this imperfection existed, that it has come to be considered as necessary, not only in this instrument, but by many it is believed to be inherent in *all music*. Instead of remedying the difficulty by introducing the sounds requisite to form the several scales (played in) perfect, and inventing such mechanism as would bring these sounds under the ready control of the organist, resort has been had to "temperament," which allows but one sound for G♯ and A♭, which makes the same note answer for A, the sixth of the key of C, and A, the key note of three sharps, which flats every fifth, sharps every major third, and leaves every musical interval (with the exception of the octave) more or less *out of tune*.

3. Various attempts have been made during the last three centuries to remedy the above difficulty, and to reduce the apparent imperfections of the musical scale to a scientific and mathematical basis. Salinas wrote on the subject as early as 1577, and the folio volume of Father Mersenne was published in French and Latin in 1648. These plans were to be effected by multiplying finger keys, which of course would augment fearfully the difficulty of

correct performance. In 1811, two patents were taken out in England for "improvements in instruments with fixed scales," an account of which, with drawings, will be found in Lond. Phil. Mag., vols. 37, 38 and 39. These were improvements in temperament only, without aiming at perfect intonation. Mr. Hawkes's system had seventeen sounds in the octave; Mr. Loeschman's had twenty-four sounds. There were mechanical as well as theoretical difficulties necessarily connected with these instruments, which were fatal to their ever coming into practical use. Rev. Henry Liston, the learned author of the article "Music" in the Edinburgh Encyclopædia, has done more in this department than any other writer. His "Essay on Perfect Intonation," in one volume quarto, was published in London in 1812. He also invented an organ designed to give the diatonic scales in perfect tune, which was built by the eminent organ-builders, Flight and Robson, of London. This was an instrument of great ingenuity, but as the inventor was a theorist rather than a mechanician, there were mechanical difficulties which alone would have been fatal to it as a practical instrument. To enable one pipe to give different sounds, Mr. Liston employed "shaders," which, arranged in classes and worked by pedals, were brought over the tops of the open, and mouths of the stopped, pipes, to alter their pitch. It is hardly necessary to remark that such mechanism was impracticable; as its correct performance required an accuracy of motion which was incompatible with the material and the nature of the instrument. There were also other mechanical difficulties in his instrument, as well as errors and omissions in his theory, (of which we shall hereafter speak,) that interfere with its claim of being an instrument of *perfect intonation*. Its harmony, however, was superior to that of the tempered organs, and is thus spoken of by John Farey, Sen., in the London Phil. Mag., vol. 37, p. 273.

"Sir: In your 27th vol., 206 p., I endeavored to call the attention of Lord Stanhope and other patrons of musical improvements, to the perfecting of an organ capable of performing in perfect tune. * * * It gives me great pleasure, therefore, to be able to state that the above is no longer a matter of doubtful speculation; but that myself and several others have heard an organ thus perfected by the Rev. Henry Liston; the exquisite effects of which, particularly in accompanying vocal music, far exceeded all that Maxwell and myself had written or perhaps conceived of the harmony of such an instrument."

Mr. Liston deserves great credit for what he *did* accomplish, and we feel much more inclined to praise him for this, than to speak of what he did *not* do. He himself frankly acknowledges the imperfections of his efforts, and concludes his essay as follows:

"After all, the subject is but just begun. I have been led to travel in some beautiful regions, unknown to such as had confined themselves to the highway. But larger discoveries remain yet to be made by those who shall, with more zeal and better qualifications, follow out the track in which it has fallen to my lot to go a little way before them."

4. The manner in which the subject of the musical scale and musical intervals is disposed of in our elementary treatises, is discreditable to music, as claiming to be a *science*. It is evident that the fundamental basis of music is not understood by those who attempt to teach the science. If it were necessary to corroborate this statement, we could refer to the blind and mysterious manner in which "temperament" is treated by modern theoretical writers. In this, which is simply an arbitrary substitution of a false note for two or more true notes, some writers have seen an "inexhaustible fountain of variety," "awful grandeur," and "exquisite beauty," while an English writer calls it an "inexplicable difficulty which no one has attempted to solve; the Deity seems to have left music in an unfinished state, to show his inscrutable power"!* Temperament is an arrangement of economy by which a small number of sounds (usually twelve to the octave) are made to answer (imperfectly of course) for the much larger number which would be required to give music in tune in the usual number of keys. This arrangement was originally submitted to, merely for the accommodation of the *instrument-maker* and the *player*. So long as no mechanism had been invented by which more than twelve sounds could be managed by the organist, temperament was necessary in instruments of this class, but this reason no longer exists, as we shall show further on in this paper. Temperament has always been considered, by the great masters, as an evil attendant upon the "present imperfect state of instrumentation,"† and hence they preferred that their instrumental music should be performed by skillful artists on violins and other instruments which admit of perfect intonation; and these have held, to the present day, their rank as the leading and most important instruments in the orchestra. It would have instructed a composer like Beethoven, or an artist like Paganini, to have heard of the scale of a modern German theorist, Kollmann, which he calls the "scale of nature," consisting "of twelve sounds in the octave placed at equal distances," on which "wonderful compound of twelve diatonic, chromatic, enharmonic scales in one," he declares "all modern music depends." The somewhat voluminous treatise of Gottfried Weber, on "musical composition," has recently been translated in this country, and has been praised as a *scientific* work. The basis from which Weber attempts to

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* Gardiner's Music of Nature, p. 433, Bost. ed., 1837.

† Beethoven.

explain musical intervals is *the key-board of a piano forte!* An interval is the distance of one piano-key from another. He defines a fifth thus: "a fifth is an interval of five places." When we consider that a common piano, with twelve notes in the octave, is *never in tune*, and cannot by any possibility be put in tune, the value of such explanations is obvious. If he had defined his intervals by reference to the *horn* or *trumpet*, as thus—that the interval between the lowest and the second notes given by the horn is an octave—that the interval between the second and third notes is a perfect fifth, and so on—his definitions could have been depended on, as the horn will *always* (if properly blown) give its intervals *exactly* thus. But so far from attempting to establish his theory on any scientific or mathematical basis, he distinctly declares, "that it is not susceptible of such an establishment, or at least, has thus far failed of proving itself to be so."

5. The writer of this paper is of opinion that music is as susceptible of a systematic and mathematical basis as chemistry, astronomy, or any other science—that what are called the "mysteries" and "imperfections" of the musical scale contain in them nothing that is mysterious or imperfect—that temperament is no longer necessary, and would be as useful applied to a multiplication table as to a musical scale—that the same sound can no more correctly represent C♯ and D♭, than the number 62 can correctly represent the two products of 6 into 10, and 8 into 8—that music is much better given *in tune* than *out of tune*—that the fundamental principles in this department of the musical science are simple, and can be expressed in a moderately concise manner. The writer is also of opinion, that many theoretical and practical musicians will look with surprise and incredulity on these statements, but he can assure them that, if they will follow him patiently and candidly through this paper, their first impressions of his opinions will be essentially modified. It may be replied that the mechanism of the organ is already sufficiently complicated, without the addition of more sounds and more machinery; and that however true the writer's theory may be, there are mechanical difficulties which render the construction and playing of a perfect instrument impracticable. If the writer was not an organ-builder by profession, and had not already overcome all difficulties that have or *can* be suggested, he might be confounded by such an objection; but since he has not only perfected a theory, but constructed and patented an instrument on the basis of his theory, (which gives its chords in perfect tune; whose mechanism is simple and *practicable;* which has a common key-board and can be played by any organist sufficiently acquainted with his profession to know what *scale* or *key* his music is in:) he appeals with confidence to his instrument to justify him in the views which he has already, and shall express. Some further reference to this instrument will be made in the latter part of this paper.

6. The writer would remark as the conclusion of his introduction, that no one, in the present unsettled state of the musical science, can expect to become thoroughly acquainted with its fundamental principles, unless he will experiment and *think* for himself. He will constantly meet with the errors of the theorists, and if he cannot detect these for himself, he will find himself in perpetual darkness. Reasoning on musical science is not different from reasoning on any other science. We must interrogate nature, and follow where she leads us, notwithstanding the time-honored opinions of the theorists. As an illustration of this we may refer to the "chord of the seventh," which consists of a common chord with a certain seventh added. If we inquire what this seventh is, we are informed by all the theorists that it is *a fourth above the fourth*, and that its ratio is 9 : 16. Upon trial, this combination we find very *discordant* and disagreeable. If we ask a good natural singer to give the note, he gives it most readily and naturally 4 : 7, a little lower than the note laid down in the books, and this note (4 : 7) we find most natural and harmonious in the chord. A *theory* should be made from the *music* and not the music from the theory.

7. We find by experiment that *if two or more sounds heard together, are in the rapidity of their vibrations in a sufficiently simple ratio, their relations are perceived by the ear, producing an agreeable sensation, and this effect we call* HARMONY.

8. If we take a series of sounds, the ratios of whose vibrations are as the following numbers, 1 : 2 : 3 : 4 : 5 : 6 : 7 : 8 : 9 : 10, &c., we have the notes which will produce a series of *chords*, which commencing with the most simple, will gradually become more and more complicated, until the ear can no longer perceive their relations: when this point is reached they will *cease* to produce *chords* and *harmony*. Any ratio, neither of whose terms, (when reduced,) is larger than 10, will produce a chord appreciable by the ear. The extent to which the relations of chords can be perceived, will vary of course in different persons according to the delicacy of the ear, and hence it may not strictly be said that there is any absolute point where chords cease and discords commence, yet as our written music contains no chord whose ratio is expressed in higher terms than *ten*, and as this last ratio 9 : 10 is certainly *near* the farthest limits of our perception, we may properly consider that all chords must have the terms of their ratios within this limit. It may be added, that though one or both of the terms be larger than 10, yet if by dividing either or both by 2, the quotient is brought within the limit above mentioned, they will still produce harmony: e. g. the chord 5 : 12 is 5 : 6 or a *minor third*, the highest note of which is raised an octave.

9. We shall then consider any combination of sounds which are, each to every other of the combination, as the ratios ex-

pressed by the numbers above, (viz., 1:2:3, &c., to 10,) as *harmonious.* Here is the fountain head from which an abundant variety of harmonies may be drawn, which can be used by the composer at his pleasure. To all sounds used in combination, which do not come within the class just named, we give the name of *discordant.* Whether such combinations shall be used, is left entirely to the taste of the composer; we only insist on this, that we shall not call them *harmony.*

10. To the chords produced by the above ratios have been given names as follows:

1:2 — Octave.
2:3 — Perfect Fifth.
3:4 — Perfect Fourth.
4:5 — Major Third.
5:6 — Minor Third.
6:7 — } These two chords have
7:8 — } not been named.*
8:9 — Major Tone.
9:10 — Minor Tone.

By combining these numbers differently we obtain different chords, e. g.:

3:5 — Major Sixth.
5:8 — Minor Sixth.
4:9 — Major (or Perfect) Ninth.
4:7 — Perfect Seventh.
5:7 — } Chords derived from
7:9 — } the Perfect Seventh,
7:10 — } and not *named.*

11. All these chords are produced from four *prime numbers,* viz., 2, 3, 5, and 7. The prime 2 produces the *octave,* the prime 3, the *perfect fifth,* the prime 5, the *major third,* and the prime 7, the *perfect seventh.* As no *prime* number can be produced from others, by any multiplication or division, so no *chord,* produced by one prime number, can be obtained from another chord produced by a different prime—*e. g.*, we cannot by tuning a series of *fifths* ever obtain the *octave* of the original note, neither by tuning *fifths,* can we obtain a *major third,* nor from either or both of these chords (thirds and fifths) can we produce a *perfect seventh. Each are original, prime chords, not resolvable one into the other.* From the neglect of these simple mathematical principles result much of the mystery and fallacy connected with temperament. It is attempted in temperament to produce a *major third* from a series of *four fifths,* or what is the same thing, an alternate series of ascending fifths and descending fourths,

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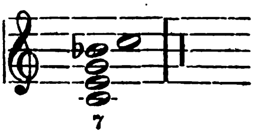
[*] It is remarkable that scarcely any mention has been made in musical treatises of these two beautiful and important chords. They are found in the chord of the Seventh. In this chord appear C, E, G, Bb, and C, whose vibrations are as these numbers, viz., $\overset{4}{C}\ \overset{5}{E}\ \overset{6}{G}\ \overset{7}{Bb}\ \overset{8}{C}$. Thus it will be seen that the ratios of G to Bb is as 6:7 and the ratio of Bb to C is as 7 to 8. The chord 4:7 we have called the *Perfect Seventh,* and for the same reason that the perfect fifth was so named. We have not called it the *minor* seventh, as the ratio of the minor seventh has always been stated so far as we have seen to be 9:16.



e. g. that $1\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}=\frac{4}{5}$ or $\frac{64}{81}=\frac{64}{80}$. Again it is supposed that a similar series of *twelve fifths* will end upon the *octave:* *e. g.*, that $1\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}\times\frac{2}{3}\times\frac{4}{3}=\frac{1}{2}$ or $\frac{524288}{531441}=\frac{1}{2}$ or $524288=531441$. But the mathematics cannot be tampered with in this manner with impunity, neither can the musical scale, which is founded upon them. The result of this mutilation is, (as might naturally be supposed,) the destruction of pure harmony and melody in the tempered music.

12. The question has been raised whether ratios which contain the *prime seven* should be considered *harmonic.* A standard elementary treatise before us contains the following: "Higher primes than 5 enter into no harmonic ratios: such combinations for instance as 1 : 7, 5 : 7, or 6 : 7, are altogether discordant. * * * * The ear will not endure them, and cannot rest upon them."*

The most certain method of determining the quality of any harmonic combination, is by an appeal to the ear. The combinations must first be *heard*, and the ear must decide upon them. Although combinations which contain the prime 7 are continually occurring in the performances of good singers and violin players, yet it might be difficult for one unfamiliar with them to know when they occur. If it be proposed to try them upon an *instrument*, it must be one of perfect intonation; *not* a common organ or piano-forte, which cannot give the chords referred to. It is probable that the writer quoted above, never heard (knowing *when* he heard them) the combinations he condemns. The writer of this paper has special facilities for the experiment in question, inasmuch as he has at hand an instrument of perfect intonation, upon which the effect of these, or any other combinations can be tried. On the evidence of his own ears and those of every musician who has heard them, he must pronounce them altogether *harmonious* and *pleasing*.†

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* Prof. Benj. Peirce, "On Sound," § 99.

† We have admitted in our system no prime *higher* than *seven*. The question may be asked, why the higher primes, as 11, 13, 17, 19, 23, &c., should be excluded? The only answer is, that they produce ratios too complicated for the ear to appreciate. These primes, and the combinations produced by them, are undoubtedly *natural*—they belong to the extended *science* of music—and would be useful were our ears sufficiently delicate to appreciate them. But although *nature's harmonies* are *illimitable*, there is a *limit* to *human perception* of them. If any one is curious to investigate this matter, he can satisfy himself by attempting to *tune* one of these remote primes, as the 11th, for instance, which will be the easiest of the whole. As this cannot be obtained from the other more simple chords, (octaves, fifths, thirds, or sevenths,) it must be tuned as an *eleventh* at once in a chord as follows, 8 : 11, 9 : 11 or 10 : 11, &c. If it be found impossible to *tune* it, it will certainly be impossible to use it in harmony or melody. If any one urge, however, that any of these primes, as the 11th for example, should be used in *practical* music for human ears, and find that he can appreciate it, (or in other words *tune* it, or know when it is *in tune*,) we will agree that it may be used by himself and those who possess equally delicate ears.

13. A *Scale* is a series of sounds, obtained from the above harmonic relations, arranged in the order of their acuteness, and it contains the notes required for the melodies and harmonies of the composition for which it is used.

14. The DIATONIC SCALE is composed of *seven* distinct notes, (the *eighth*, being the octave, is regarded as a repetition of the first.) It is formed by combining the chords of perfect fifth, (2:3,) and major third, (4:5,) and it contains all the intervals and chords which have been named, with the exception of those derived from the perfect seventh. Assuming C as a key-note, this scale, in the vibrations of its several notes, stands as follows:

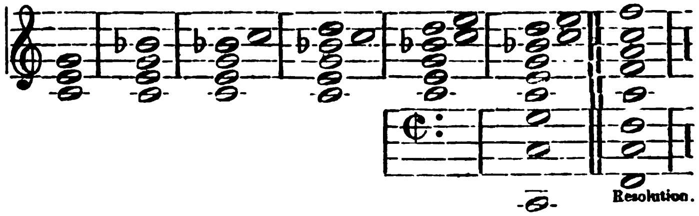
C		D		E		F		G		A		B		C
Key-note.		Second.		Third.		Fourth.		Fifth.		Sixth.		Seventh.		Octave.
24	:	27	:	30	:	32	:	36	:	40	:	45	:	48
	Maj. T.		Min. T.		S.		Maj. T.		Min. T.		Maj. T.		S.	

15. On examining the relations of these numbers, we find the intervals which separate the several notes of the scale. The ratio of 24:27 or 8:9, gives the interval between the first and second notes, which is called *major tone*. The ratio of 27:30 or 9:10, gives the interval between the second and third notes, which is called *minor tone*. The interval by which the major tone exceeds the minor is called *comma*, whose ratio is 80:81. The ratio of 30:32 or 15:16, expresses the interval between the third and fourth of the scale, and it is called *diatonic semitone* or simply *semitone, diatonic* being understood. From the fourth to the fifth, and from the sixth to the seventh, is the same as from the key-note to the second, i. e., major tone. From the fifth to the sixth is the same as from the second to the third, i. e., minor tone, and from the seventh to the eighth is the same as from the third to the fourth, i. e., diatonic semitone.

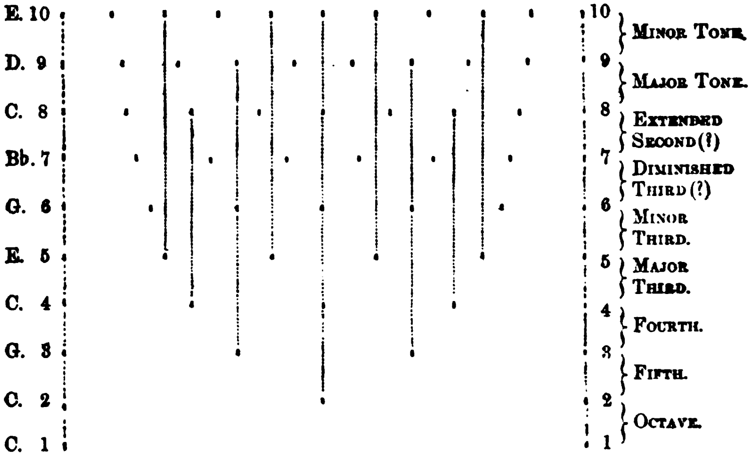
16. Besides the diatonic semitone, there are used in composition two others, resulting from taking the diatonic semitone from either tone. If it be subtracted from the *major* tone, it leaves what is called the *chromatic semitone*, and if taken from the *minor* tone, there remains the *grave chromatic semitone*, comma less than the chromatic.

17. If from any note, as key-note, there be taken a *perfect fifth* and *major third*, the three notes sounded together will produce a *common chord*. These notes are, in their vibrations, as these numbers, viz.:. 4:5:6. If to this, the *perfect seventh* (4:7) be added, we have the *chord of the seventh*, expressed thus, 4:5:6:7. Adding the *octave*, the chord becomes 4:5:6:7:8. To this may be added the *major ninth* (4:9), producing this chord, viz.: 4:5:6:7:8:9. And finally, by adding the *tenth*, (or octave and major third), we obtain this chord, viz.: 4:5:6:7:8:9:10. By adding, below the key-note, the double-octave, its octave and twelfth, we have what may be called the *full chord of the tenth*,

viz.: 1:2:3:4:5:6:7:8:9:10. All of these chords are perfectly harmonious, and in all respects appreciable by the ear. The last contains within itself every musical chord and harmony, that can be obtained from ratios whose terms do not exceed ten. Examples of these chords, as written, we here exhibit.

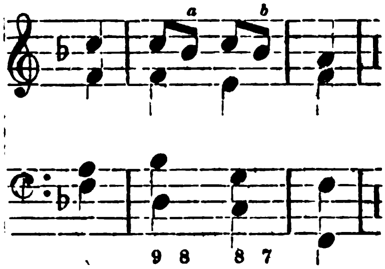


The vibrations in the various ratios of the full chord of the tenth may be represented to the eye by the following diagram.

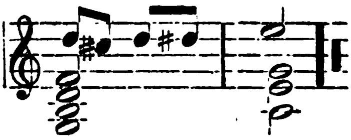


Assuming any length of time, for a single vibration of the lowest note, it is evident that the other several notes of the chord will in the same time perform vibrations, equal in number to the numbers expressing their ratios respectively; and that at the expiration of this time, the vibrations of every note will coincide with each other. There are also points within this assumed time in which two, three, four or more of these notes will coincide in their vibrations. These coincidences are represented in the diagram by dotted lines. By means of the diagram, the vibrations of any other chord, as the common chord, the chord of the seventh, ninth, &c., may be examined, as they are all contained in the full chord of the tenth. The difference in the effect of the different chords is seen in the less frequent coincidences in the more complicated chords. Thus the octave is much more simple than the major tone, for the reason that every vibration of one of its notes, coincides with every second vibration of the other, while in the major tone it is necessary that that one note perform *eight*, and the other *nine* vibrations before there is any coincidence. And from this, will appear the increased difficulty in *tuning*, as the chords become more complicated.

18. From the introduction of the perfect seventh is obtained another interval, viz.: the difference between the *fourth* of the scale, and the *dominant seventh*, (i. e. the perfect seventh upon the fifth of the scale.) In this example, we have a melody in which these two notes appear. At *a*, B♭ is the fourth of the scale of F, while at *b*, it is the perfect seventh to C; and the last B♭ is lower than the first by about a comma and a quarter. Consequently in singing the melody with the accompaniment as written, the voice will give the second B♭ lower than the first by that interval. It will be found on experiment, that a good natural singer, if asked to sing the melody with this accompaniment, will naturally, and no doubt unconsciously, make the distinction referred to.

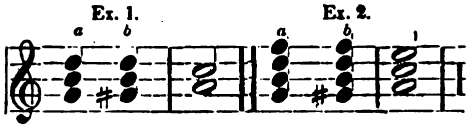


19. As it has been stated that musical ratios, in order to be harmonious, must not exceed a certain limit of simplicity, the question naturally arises, shall no other notes be heard together in music but those which have, each to every other, these simple ratios? Abundant examples can be selected from the best composers, in which notes are heard together, which make more complicated ratios, and which cannot be regarded as *harmonious*. To illustrate this we take the following example. With the chord of the dominant seventh as accompaniment, are heard at the same time the notes D, C♯, D and D♯. The melody in the first and third notes is in harmony with the accompaniment. But though C♯ and D♯ appear, while the chord is sounding, they can make no *harmony* with it. Neither are they *discordant*. The ear regards the progression of these notes as parts of the melody, and only requires that the melodic intervals (diatonic and chromatic semitones) be given truly, without regarding the *ratios* which the accidentals make with the accompanying chord. In other words, these are PASSING NOTES, which have nothing to do with the *harmony*, and are to be thrown out when we would find the notes which compose the



chord. Many apparently complicated combinations may be made simple, by attending to this department of *passing notes.*

20. There is a certain combination of sounds, which has occupied a separate department of most treatises. It is called the "chord of the diminished seventh," and is supposed to possess some peculiar and extraordinary qualities. It would, of course, not be treating this chord, which has received so much attention hitherto, with proper respect, to pass it over in silence. It is defined to be, and undoubtedly is, exactly like the chord of the seventh, with the exception that the lowest note (of the chord of the seventh) is in the "diminished seventh," raised a chromatic semitone. It is supposed that there exists in this combination a "*harmony*" which is peculiar[*] and altogether different from that found in the chord of the seventh. In the first example, the first chord is the common chord of G. It is intended to pass from this to the minor chord of A. Now, although we might pass from the chord of G, directly to that of A, it is judged expedient to have the melody of the lowest part, instead of ascending by a whole tone at once, ascend by two steps, viz., a chromatic and diatonic semitone. The G♯ introduced, does not belong to the harmony, but is merely a *passing note.* The matter is very easily understood in this first example. The second example is precisely like the first, with the exception that the seventh has been added to the chord, and it would have been equally easy to understand, had not the subject been darkened by the "words without knowledge," of the theorists who have written on the "diminished seventh." For if in the first example, G♯ is a passing note, why should its effect be changed by the addition of the *seventh* to the chord? It is stated by the theorists that the *root* of the chord at *a* is G, but that at *b* (when G is changed to G♯) the root changes to *E*. Now, as by the *root* of a chord is meant a note with which the remaining notes will be in a simple ratio, and will *harmonize,* we will inquire how this *root,* E, major third below G♯, will harmonize with the other several notes of the chord. The ratios of the vibrations of these several notes will be as follows:



E	G♯	B	D	F
20	25	30	30	42

From these ratios we see that E will be discordant with F, (making the ratio 20:42, or 10:21), and G♯ will be discordant with D and F (25:36, and 25:42), making altogether not very *harmonious* "harmony." Indeed, the difficulty of treating the chord in this manner has caused considerable discussion, which some have endeavored to surmount, by calling it a "dissonant chord," or "dissonant *harmony!*" It is stated, (and with reason,) that "this root E must not be heard in the chord, as it is discordant." It is certainly remarkable if, in this chord alone, the *root* does not happen to be in harmony with the other members of the chord. But if G♯ be considered as a *passing note*, we shall at once be sure as to what the chord is. The root will be G, and every note (with the exception of G♯, the passing note, which must be thrown out when we reckon the harmony,) is in perfect tune with it, in a simple and harmonious chord, viz., 4:5:6:7. And this G♯ appears to us as plainly to be a passing note, through which the melody of the lowest part passes from G to A, (for after this note we always have A,) as that D♯ is a *passing note* from D to E, in the example given in (19.) In this example, in the chord at *a*, it would probably be admitted without dispute that G♯ was merely a passing note; and why it should be considered as any thing else, when it appears at *b*, could not, we think, easily be made manifest. We shall therefore consider that there is no different *harmony*, in what has been called the "chord of the diminished seventh," than exists in the "chord of the seventh;" and for this reason, that all the harmony it contains is derived from, and found in, the chord of the seventh.

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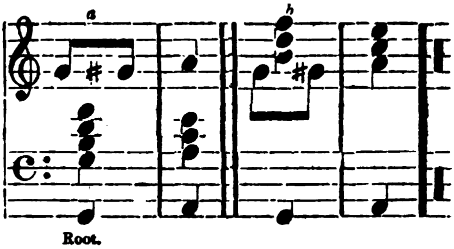
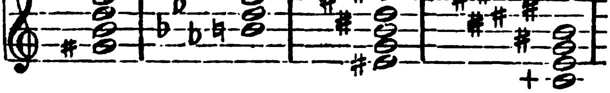
[*] Wm. Gardiner, in his "Music of Nature," gives the following as his idea of this chord. "If four minor thirds (!) be combined, they form the chord of the extreme flat seventh, which excites in us fear and alarm, because it is a clatter of sounds indicating rage and ferocity. These tones escape us in the ebullitions of our worst passions, and are heard in the savage murmurs of wild beasts."



21. Among the many mistakes and incongruities into which the theorists have been led by the temperament of the scale, and their constant habit of referring all combinations to the key-board of the piano-forte or organ, is the following idea in regard to this "diminished seventh." It is supposed that a chord of the diminished seventh contains the sounds which belong to *four* different and remote scales, and thus connects them together. Here are examples of four of these chords in the keys of C, E♭, A, and F♯; they are, as will be seen, the chords of the dominant sevenths of those keys, with the lowest notes raised a chromatic semitone.



It is supposed that each of these four chords contains the *same identical sounds:* and on the piano-forte, it is impossible to obtain any other than the same sounds, in the four different keys. These four chords have therefore been allowed to be one and the same thing. Mention is, indeed, made of the "*enharmonic change*" of G♯ to A♭, F to E♯, D to C+, &c.; but as on the piano forte it is impossible to make any change—that instrument having but one sound to answer for the two or more, which appear in the written music—the idea has prevailed that the change is merely *imaginary*, and that the alteration in the mode of writing the note, is made only to prevent one key from being mistaken for another, in the appearance of the written music to the eye. But the truth is, that in *perfect intonation*, an enharmonic change always means the *alteration* of a note by a small interval. And not only are enharmonic changes made when the written music shows a *sharp* changed to a *flat*, and *vice versâ*, but *changing the signature* will often produce an enharmonic change. This point will be more fully illustrated when we have spoken of transposition and modulation, and explained our *system of notation.**

22. As musical composition would be very limited in variety, if confined to a single scale or key, other scales have been constructed on new key-notes, separated one from the other by intervals of perfect fifths, and from these key-notes, the remaining notes of each scale are placed at the same intervals which were adopted in the construction of the original. If we take the fifth of any scale as the key-note of a new scale, and complete it with the same intervals as the first, we shall find that *two sounds* will be introduced which were not found in the original scale. We take for example the diatonic scale of C, and assuming its fifth G as key-note, complete the scale of G. The second of this scale will be A, and from G to A, or the first to the second, must be a *major tone*, (15.) On examining the scale of C, (14) we find that the A of that scale is but a *minor tone*, from G. We must therefore introduce a *new A*, a comma higher than the first, and a major tone from G. Every other note of the C scale is correct for the G scale with the exception of F, which must be raised a *chromatic semitone* to F♯, to form the seventh of the scale of G. In general, the scale may be transposed to any extent by the following rules.

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* The writer has been led into this digression on the subject of the "diminished seventh," from the fact, that it has been treated, as he considers erroneously, in all the scientific musical works that have fallen under his observation, and it has been urged as an objection to a system of perfect intonation. Since the article was in type, a friend of extensive musical study informs him, that such views as Weber and others have expressed on the diminished seventh, have been rejected by Vogler and the best German theorists.

23. *To transpose the scale to the fifth above; the* SIXTH *must be raised a* COMMA, *and the* FOURTH *a* CHROMATIC SEMITONE *to form the* SECOND *and* SEVENTH *of the new scale.*

And to transpose it to the fifth below, the process must be reversed: i. e.: the SECOND *must be lowered a* COMMA, *and the* SEVENTH *a* CHROMATIC SEMITONE, *to form the* SIXTH *and* FOURTH *of the new scale.*

24. By this system of transposition we obtain two or more different notes expressed by the same letter—two A's for instance, as we have shown above. To make it obvious to the eye, which of several notes of the same letter belongs to any required scale, we have adopted the following *system of notation.* Every note of the diatonic scale of C, we mark with a figure 2; as thus: C^2, D^2, E^2, F^2, G^2, A^2, B^2, C^2. When in transposition one of these notes is raised a comma, enharmonically,* it is marked with the higher number 3; and when it is lowered a comma it is marked with 1. Thus A^3 will signify a note a comma higher than A^2, the A of the C scale; and D^1, a note a comma lower than D^2. The sharps and flats will also be marked 2, when they first appear in transposing from C to the keys above and below. We now exhibit the scales of C, and of G and F, whose key-notes are the fifths above and below C, with the names of the notes of each, and their intervals. It will be seen that the order of the intervals from the key-note is made the same in each, by the alteration of the two notes in each adjoining scale.

Scale of G. 1#	4		5		6		7		KEY.		2		3		4
		Major T.		Minor T.		Major T.		S.		Major T.		Minor T.		S.	
	C^2		D^2		E^2		$F\sharp^2$		G^2		A^3		B^2		C^2
Scale of C. ♮	KEY.		2		3		4		5		6		7		8
		Major T.		Minor T.		S.		Major T.		Minor T.		Major T.		S.	
	C^2		D^2		E^2		F^2		G^2		A^2		B^2		C^2
Scale of F. 1♭	5		6		7		KEY.		2		3		4		5
		Minor T.		Major T.		S.		Major T.		Minor T.		S.		Major T.	
	C^2		D^1		E^2		F^2		G^2		A^2		$B\flat^2$		C^2

25. The following table exhibits the diatonic scales from five flats to five sharps. The table might have been extended both above into more sharps, and below into flats without limit; and any number of signatures might have been thus obtained; but we have here given but eleven of those most frequently used.

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* An *Enharmonic change* is a change by any interval smaller than a chromatic or diatonic interval, as for instance, the difference between the major and minor tones—between G# and A♭—the fourth of a scale and its dominant seventh, &c. These enharmonic changes are not usually expressed in notation, except by the *signature*, but they are necessary to perfect intonation, to bring the music "into harmony," which is implied in the derivation of the term, ἐν and ἁρμονία.

In addition to the diatonic scales, we have added three columns, viz., the leading notes or sevenths of the *minor scales*—the perfect sevenths—and the dominant sevenths, (or the perfect sevenths upon the dominants.)

Signatures.	Key Notes.	Major Seconds.	Major Thirds.	Dominant Sevenths.	Perfect Fourths.	Perfect Fifths.	Leading notes, Minor scales.	Major Sixths.	Perfect Sevenths.	Major Sev-enths.	Octaves.
5 Sharps.	B^3	C♯^{3}	D♯^{2}	E7	E^3	F♯^{3}	F+^{1}	G♯^{2}	A7	A♯^{2}	B^3
4 Sharps.	E^3	F♯^{3}	G♯^{2}	A7	A^3	B^3	B♯^{1}	C♯^{2}	D7	D♯^{2}	E^3
3 Sharps.	A^3	B^3	C♯^{2}	D7	D^2	E^3	E♯^{1}	F♯^{2}	G7	G♯^{2}	A^3
2 Sharps.	D^2	E^3	F♯^{2}	G7	G^2	A^3	A♯^{1}	B^2	C7	C♯^{2}	D^2
1 Sharp.	G^2	A^3	B^2	C7	C^2	D^2	D♯^{1}	E^2	F7	F♯^{2}	G^2
Natural.	C^2	D^2	E^2	F7	F^2	G^2	G♯^{1}	A^2	B♭7	B^2	C^2
1 Flat.	F^2	G^2	A^2	B♭7	B♭^{2}	C^2	C♯^{1}	D^1	E♭7	E^2	F^2
2 Flats.	B♭^{2}	C^2	D^1	E♭7	E♭^{2}	F^2	F♯^{1}	G^1	A♭7	A^2	B♭^{2}
3 Flats.	E♭^{2}	F^2	G^1	A♭7	A♭^{2}	B♭^{2}	B^1	C^1	D♭7	D^1	E♭^{2}
4 Flats.	A♭^{2}	B♭^{2}	C^1	D♭7	D♭^{2}	E♭^{2}	E^1	F^1	G♭7	G^1	A♭^{2}
5 Flats.	D♭^{2}	E♭^{2}	F^1	G♭7	G♭^{2}	A♭^{2}	A^1	B♭^{1}	C♭7	C^1	D♭^{2}

In the above table, the column marked "major sixths," contains also the *key-notes of the minor scales.* These key-notes, as will be seen, are a comma lower than the notes of the same letter, which are key-notes of *major scales*, e. g., the key-note of *C minor* (being the relative minor of E♭, in the scale of three flats) is C^1, comma lower than C^2, the key-note of *C major*, in the natural scale. Consequently the leading notes of the minor scales (which are diatonic semitone below their key-notes, and major third above the major third of the relative major scale,) are lower than the key-notes of the major scales by the same interval, viz., a comma. In the column of "perfect sevenths," and "dominant sevenths," the figures are attached to the letters arbitrarily, and not according to the system adopted for the others, (24.) Being derived from a *prime* different from the notes of the diatonic scale, they will not vary from them by even commas. They are marked 7, and their pitch is about a comma and a quarter* below that of the letters of the same name in the column of "perfect fourths," and each is always used (as a *seventh* only) in one chord and no other.

26. Having explained our system of notation, and having before us a table, which contains the exact relative pitch of every note, in eleven major, and eleven minor scales, we are prepared to recur to the illustration we gave concerning the "diminished sev-

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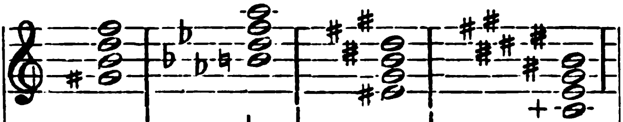
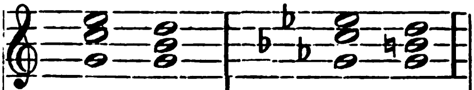
* The ratio of this interval is 68 : 64, and consequently larger than the comma, 80 : 81.

enth," (21.) We again give the example, and also place below the notes, as given in the table. It will be seen that each of the chords is entirely different—that not a note found in any one of the chords, is found in any other.



F^7	A♭^{7}	D^7	B^7
D^2	F^2	B^3	G#^{3}
B^2	D^1	G#^{2}	E#^{2}
G#^{1}	B♮^{1}	E#^{1}	C+^{1}

27. We find it stated in certain theoretical treatises, "that the major and minor keys of the same letter," (as C major, and C minor) "are nearly related, inasmuch as the two tonic chords are alike, with the exception of the third, and both have the same dominant chord." We will write the tonic and dominant chords of C major (in the natural scale,) and of C minor (in three flats,) and from the table, ascertain the notes of each. We find the notes of the two keys entirely different, and consequently C major is not related to C minor, except in the *fourth* degree, through the following keys, viz.: F, B♭, E♭, and C minor. As upon the keyed instruments, it has been necessary to use the same sounds in C major and C minor, the writers, referred to, were led to make the statement we have quoted.*



C Major.		C Minor.	
E^2	D^2	E♭^{2}	D^1
C^2	B^2	C^1	B^1
G^2	G^2	G^1	G^1

(*To be continued.*)

Art. XIII.—*Analyses of several Minerals*; by William Fisher.

The following analyses were performed in the Laboratory of Prof. Booth, whose guidance in their performance I acknowledge with pleasure.

1. *Green sand* from New Jersey, a few miles southeast of Philadelphia. It is blueish green, soft and adhesive when moist, in large and hard grains when dry, and containing a trifling admixture of quartz sand. The analysis was performed in the usual

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* A description of the Euharmonic Organ is necessarily postponed to the next number of the Journal. The instrument, however, in a few days, will be set up in Boston, and will be exhibited with pleasure, to those who are interested in the progress of musical science. The writer will be found at No. 18, North Russell street.

manner of a soluble silicate, the soda and potassa being separated by chlorid of platinum. Phosphoric acid was carefully sought for by several processes and by repeated trials without success. The following are the results:

Silica,	53·26
Alumina,	3·85
Protoxyd of iron,	24·15
Magnesia,	1·10
Lime,	1·73
Soda,	1·60
Potassa,	5·36
Water,	10·12
	101·12

2. *Vivianite* from the green sand of Delaware, about four miles west of Cantwell's Bridge. The beauty of the crystals, and the similarity of some of the specimens with Thompson's mullicite induced me to investigate them. The mineral is perfectly crystallized in oblique rhombic prisms, with several terminal planes, and a brilliant cleavage parallel to a lateral end plane. Although the prismatic planes reflect a good image, yet their intervening edges are rounded like the apatite from Rossie, N. Y. When first obtained from the green sand, the crystals were perfectly colorless, but in the course of some weeks changed to a light green color, still, however, retaining their transparency. The phosphoric acid was separated both by sulphuret of ammonium and by fusion with potassa, and the state of oxydation of the iron was ascertained by solution in muriatic acid apart from the air and by carbonate of baryta. The results are:

Phosphoric acid,	27·17
Protoxyd of iron,	44·10
Water,	27·95
Silica,	0·10
	99·32

The analysis shows that the formula is that given to vivianite. In a late number of his Annual Report, Berzelius calculated a different formula from a partial peroxydation of the iron; but the above well crystallized specimen indicated only a slight amount of oxydation, and the change in color of the mineral after removal from the green sand, indicated this oxydation. The true formula is therefore $3FeO, PO_5+8HO$.

3. *Garnet*, from Franconia, New Hampshire. Part of the specimen exhibited the usual characters of colophonite, but the projecting points of some of the coarse grains showed the crystallization of garnet in a combination of the 24-hedron, and

48-hedron. The analysis, performed like that of a silicate, fused with carbonate of soda, gave:

Silica,	38·85
Peroxyd of iron,	28·15
Lime,	32·00
	99·00

It therefore agrees with the purest lime-iron-garnet, and its formula is $3CaO, SiO_3 + Fe_2 O_3, SiO_3$.

4. *Chondrodite*, from New Jersey. Some very dark red specimens appearing to indicate the presence of oxyd of zinc, which occurs so abundantly in that mineral district, the analysis was chiefly undertaken to determine this point. The fluohydric acid was determined by fusion with carbonate of soda, and by subsequent treatment of the aqueous solution by oxyd of zinc, sal-ammoniac, ammonia and chlorid of calcium. The results corresponded with one of Rammelsberg's analyses and the absence of zinc was fully proved. The analysis gave:

Silica,	33·35
Magnesia,	53·05
Protoxyd of iron,	5·50
Fluorine,	7·60
	99·50

The formula is therefore $MgF + 2\,(3MgO, SiO_3)$, in which a portion of the magnesia is replaced by protoxyd of iron.

Art. XIV.—*Memorials of John Bartram and Humphry Marshall, with notices of their Botanical Contemporaries*, by Wm. Darlington, M.D., LL.D., pp. 585, 8vo. Philad., 1849.

It is pleasant to see these memorials of our two patriarchs in natural history, the two earliest native-born and self-taught American botanists. And fit it is that the duty of rescuing these remains from oblivion and fast approaching decay should have fallen to the lot of one who has such a genuine fondness for these old records, and to whom the task of deciphering and editing them is truly a labor of love. Dr. Darlington, the pupil of Barton, who flourished one full generation after Bartram and Marshall, now ranks—so rapid is the flight of time—among the oldest of our surviving botanists, though with eye undimmed and natural force unabated, still ready for every good work.

In the *Reliquiæ Baldwinianæ*, he, several years ago, paid a fitting tribute to the memory of the friend and companion of his youth; the leisure hours of the last year and more have been devoted to collating, copying with his own hands, and editing the mouldering and often hardly legible correspondence of these earliest cultivators of his favorite science in his native state, and, we believe, the earliest indigenous botanists of the new world.

Instead of elaborating anew the materials for a biography of the elder Bartram, Dr. Darlington has reproduced the meagre sketch which was prepared by his son William, and published in Barton's *Medical and Physical Journal* in the year 1804, as in the main more reliable than any other. Its incompleteness, however, may be gathered from the fact, that it does not, nor does any other published biography, mention the name of Bartram's father, "nor could any of his descendants, enquired of by the editor, furnish that name, neither could they give the exact date of the botanist's birth!" These desiderata are now supplied, through Dr. Darlington's diligence, and the kindness of a friend who obtained them from the ancient records of Darby Monthly Meeting. It appears that he was born "near the village of Darby, in Delaware (then Chester) County, Pennsylvania, on the twenty-third day of March, 1699; that his great-grandfather, Richard Bartram, lived and died in Derbyshire, England; leaving an only son, John, who married in Derby, lived for some years in the town of Ashborn, and in 1682—the year in which the city of Philadelphia was founded—emigrated to Darby, Pennsylvania, with three sons, two of whom died unmarried. The third, William, was the father of John Bartram the botanist.

The latter received such scanty education as the country schools of the colony furnished; and he appears to have obtained, through his own endeavors, some elementary acquaintance with Latin and Greek; but not until his taste for natural history was developed, which, however, must have been early in life. For he was still a young man when he removed from the farm he had inherited from his uncle, and purchased a piece of ground on the Schuylkill, near Philadelphia, for the establishment of the well known garden that bears his name, and built with his own hands (A. D. 1731) the large and comfortable house of hewn stone which is still standing, and which Dr. Darlington has depicted in a large wood-cut which forms the frontispiece of his volume. To him is attributed, we believe justly, the credit of having been "the first Anglo-American who conceived the idea of establishing a botanical garden for the reception of the various vegetables, natives of the country as well as of exotics; and of travelling for the discovery and acquisition of them." He certainly established the first garden of the kind in this country, and filled it with our choicest plants and trees, then in great part novel to botanists. It was not his fault that it was not the nucleus of a public institution, endowed through the wealth and spirit of a prosperous metropolis, instead of sinking into neglect and becoming the site of a coal-yard.

"He began his travels at his own expense. His various excursions rewarded his labors with the possession of a great variety of new, beautiful and useful trees, shrubs and herbaceous plants. His garden at length attracting the visits and notice of many virtuous and ingenious persons, he was encouraged to persist in his labors." This naturally led to a correspondence with the naturalists of Europe. His earliest and his principal correspondent was Peter Collinson, the London merchant, and member of the Royal Society, a most amiable man, dear old gossip, who loved above all things to receive novelties and accounts of curious things from distant parts and to share them with the savans of the day. He is well known by his correspondence with Linnæus, published by Sir James E. Smith, and with Franklin, published in President Sparks's collection of the philosopher's writings and correspondence; and a portion of his characteristic letters to Cadwallader Colden may be remembered by the readers of this Journal.* His letters to Bartram occupy more than half the bulk of the correspondence now published, and exhibit the good London merchant in a very pleasing light. They cover the whole period from 1734 to Collinson's death in 1768, a period of thirty-four years; and the earliest of the series found among the Bartram papers evidently does not commence the correspondence. The originals of the letters addressed by Bartram to Collinson are probably not extant. Those here published are from copies or original draughts preserved by the writer. The first of the series is dated May, 1738; so that we have none in reply to those of Collinson during the four earlier years, which is much to be regretted.

In the second letter here published, the good Collinson initiates John Bartram into the art and mystery of preparing dried specimens of plants. The botanist of the present day may be somewhat surprised to learn that a "quire of whited-brown paper" was thought amply sufficient to hold a year's collection.

"London, January 24th, 1735.

"My good friend, JOHN BARTRAM:—I am very much obliged to thee for thy two choice cargoes of plants, which came very safe and in good condition, and are very curious and rare, and well worth my acceptance. I am very sensible of the great pains, and many tiresome steps to collect so many rare plants scattered at a distance. I shall not forget it; but in some measure to show my gratitude, though not in proportion to thy trouble, I have sent thee a small token: a calico gown for thy wife, and some odd little things that may be of use amongst the children and family. They come in a box of books to my worthy friend, Joseph Breintnall, with another parcel of waste paper, which will serve to wrap up seeds, &c. But there is two quires of brown, and one of whited-brown paper, which I propose for this use and purpose, and will save thee a great deal of trouble in writing: that is, when thee observes a curious plant in flower, or when thee gathers seed of a plant thee has an intention to convey me a description of, on both these occasions, thee has nothing more to do than to gather branches or sprigs of the plants, then in flower, with their flowers on, and with their seed-vessels fully formed; for by these two characteristics, the genus is known that they belong to. Then take these, and spread them between the sheets of brown paper, laying the stems straight and leaves smooth and regular; and when this is done, put a moderate weight on a board the size of the paper. In two days remove the specimens into the other quire of brown paper, keeping the weight on; and then in a week or two, being pretty well dried, convey them thence into the quire of whited-brown paper. Thus, when now and then thee observes a curious plant, thee may treat it in this manner, by which thee will convey a more lively idea than the best description; and when thee gathers seeds, mark the same number on the seeds as thee marks in the sheet where the specimen is, only writing under it the country name. So, once a year, return me the quire of whited-brown paper, with the dried specimens tied fast between two broad boards; and then I will send some more in their room. When the sheet of paper will hold it, put one, two, or three specimens of the same plant in the same sheet, so they will but lie smooth by each other.

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* Selections from the scientific correspondence of Cadwallader Colden, vol. xliv, p. 85, 1843.

"Besides, what I have further to propose, per this method, is, thy own improvement in the knowledge of plants; for thou shalt send me another quire of duplicates of the same specimens; I will get them named by our most knowing botanists, and then return them again, which will improve thee more than books; for it is impossible for any one author to give a general history of plants. Let the specimens be of the length of the paper.

"Thee canst not think how well the little case of plants came, being put under the captain's bed, and saw not the light till I went for it; but then Captain Wright had a very quick passage; and it was put on board in a right month, for when plants are down in the ground, and in the winter months, they may be stowed anywhere; but it must not be attempted any time this side Christmas."

* * * * * * *

"I wish, at a proper season, thee would procure a strong box, two feet square, and about fifteen or eighteen inches deep,—but a foot deep in mould will be enough; then collect half a dozen laurels, and half a dozen shrub honeysuckles, and plant in this box; but be sure make the bottom of the box full of large holes, and cover the holes with tiles, or oyster-shells, to let the water drain better off. Then let this box stand in a proper place in thy garden, for two or three years, till the plants have taken good root, and made good shoots; but thee must be careful to water it in dry weather.

"I wish that thee would not fail to put three or four specimens of the sprigs of the laurel, with the flowers fully blown (for I long to see it) in the paper, transferring them from one to another, as I have directed. As my design is not to give thee more trouble, so a few specimens will content me.

"I have further to request thee to put up a little box of plants (yearly) in earth, such as thou finds in the woods, that are odd and uncommon.

"What thee observes of the frost, to be sure, had the effect thee describes. I once remember one like it in England; but the effects were not so severe. I hope, next year, thee will be able to make some selections that may make thee some returns.

"The White Flowering Bay [*Magnolia glauca, L.*] is a plant that grows in moist places; the leaves are long, of a bay shape, and of a silver color on the back of the leaves. It bears a fine large white flower, like the water lily, of a fine perfumed smell, which is succeeded with a seed-vessel of a cone-like figure. I have a plant that flowers finely, in my garden. It is in abundance of places, in Maryland; but whether it is found more northward, I can't say. It is a fine plant to adorn thy own garden. But give thyself no trouble about it: and, as the fir and cypress cones are not found near thee, we will wait for some more favorable opportunity to collect them. Send first those seeds that are near thee.

"The box of seeds came very safe, and in good order. Thy remarks on them are very curious; but I think take up too much of thy time and thought. I would not make my correspondence burdensome; but must desire thee to continue the same collections over again; and to prevent trouble, only number the papers, and give the country name—or any name thee may know it by again; then keep a list of them by thee, with the number to the names, and when they come here, those that do not come up, we have only to write to thee for the same seed to such a number, to send over again. As I design to make a present of part of these seeds to a very curious person [Lord Petre,] I hope to procure thee some present for thy trouble of collecting. I am thy very sincere friend. P. COLLINSON."—pp. 63–65.

This letter proves that it was Collinson's forethought and care which suggested the plan for making Bartram's collections afford some reimbursement, and furnish the means for new journies and explorations. A paragraph in a succeeding letter shows that he had interested Lord Petre in the undertaking.

"London, March 1st, 1735.

"Kind friend, JOHN BARTRAM:—I am now just returned to town from paying a visit to a noble lord, my most valuable and intimate friend. One of my proposals, I sent thee last year, to collect the seeds of your forest trees, was for him, as he is a universal lover of plants. I presented him with a share of the seeds thou sent last year, which was very acceptable. As he is a man of noble and generous spirit, he very rationally considered thy pains and trouble in collecting them, and desired to make thee some returns, and left it to me. I thought a good suit of clothes, for thy own wear, might be as acceptable as anything, so have sent thee one, with all appurtenances necessary for its making up, which I hope will meet with thy approbation, and help in some measure to compensate for thy loss of time.

"My noble friend desires thee to continue the same collections. Send the same sorts over again, and what new ones happens in thy way, and sent at the same time o' year, and in the same manner, will do very well. Please to look in my other letter for my further remarks on this head. * * * *

"As our noble friend will be always grateful, I hope it will encourage thee to go on; but yet I would have thee so proceed as not to interfere with thy private business. Indeed, the forest tree seeds I hope will bring money into thy pocket; so the time spent in making the collection cannot be said to be lost or misspent. * *

"I hope thee hath mine per Captain Richmond; with a parcel in the Library Company's trunk, and a box of seeds, in sand, per Richmond. I heartily wish thee and thine health and prosperity, and am

Thy real friend, P. COLLINSON.

"Pray give nobody a hint, how thee or thy wife came by the suit of clothes. There may be some, with you, may think they deserve something of that nature.

"If thee observes any curious insects, beetles, butterflies, &c., they are easily preserved, being pinned through the body to the inside of a little box. When it is full, send it nailed up, and put nothing within it, and they will come very safe. Display the wings of the butterflies with pins, and rub off the down as little as possible. When thee goes abroad, put a little box in thy pocket, and as thee meets with them put them in, and then stick them in the other box when thee comes home. I want a *Terrapin* or two. Put them in a box with earth, and they will come safe. They will live a long while without food."—pp. 69, 70.

We must make room for a part of the preceding letter, evidently in reply to one in which Bartram had reproached his correspondent for not sending him the English seeds and plants he had asked for.

"I have procured from my knowing friend, Philip Miller, gardener to the Physic Garden at Chelsea, belonging to the Company of Apothecaries, sixty-nine sorts of curious seeds, and some others of my own collecting. This, I hope, will convince thee I do what I can; and if I lived, as thou does, always in the country, I should do more; but in my situation it is impossible. Besides, most of the plants thou writes for, are not to be found in gardens, but growing spontaneously a many miles off, and a many miles from one another. It is not to be expected I can do as thou does. My inclination's good, but I have affairs of greater consequence to mind; and as I have observed to thee before, affairs of this nature should not interfere with business, and I do request thee not to suffer anything thee does for us to interfere with thine. Indeed, for the cargo thou sent, there was some reason for thy making it thy business, because thee will have some gratification; but in thy other curious collections, which is done purely to oblige us, pray give thy business the preference; but if, in the course of that, without neglecting it, thou can pick up what thou thinks will be acceptable, we shall be obliged to thee, and study some requital. So for the future, no more censure me for not sending the one-sixth part thee wrote for,

for the reasons above; but yet transmit me yearly what thou wants, and any thing in my power, or my friend Miller's, will be always at thy service; and if I send thee the same thing two or three times over, thee must excuse it, and place it to the multiplicity of affairs that fill my thoughts, and not suspect my care; and then thee will deal kindly, and friendly, and lovingly, by P. Collinson."—pp. 68, 69.

The next letter informs Bartram that his collection of seeds of forest trees had brought £18 13*s*. 3*d*. from Lord Petre, who also promised an annual subscription of ten guineas to aid him in making further discoveries.

"Lord Petre is very willing to contribute very handsomely towards it. He will be ten guineas, and we are in hopes to raise ten more. This we think, will enable thee to set apart a month, two, or three, to make an excursion on the banks of the Schuylkill, to trace it to its fountain. But so great an undertaking may require two or three years, and as many journeys, to effect it, so we must leave that wholly to thee. But we do expect, that after harvest, and when the season is that all the seeds of trees and shrubs are ripe, thou will set out; and them that happen not to be ripe when thou goes, they may have attained to maturity when thou comes back. We shall send thee paper for specimens and writing, and a pocket compass,—expect thee'll keep a regular journal of what occurs every day, and an exact observation of the course of the river, which, with a compass thee may easily do." —p. 12.

Again, the next letter.

"I have now the pleasure to tell thee that I have got subscribed twenty guineas, to encourage thee to undertake thy intended expedition; and as our gentlemen find encouragement, it will be continued annually. This is a pretty sum in sterling money, which I hope will enable thee to supply thyself with necessaries from hence; or, if more for thy profit, thou may draw for it when we have received thy cargoes. This, I believe, thee will think reasonable, that the gentlemen should first see what they have for their money. This I can assure thee, that thee has to do with people that are not unreasonable in their expectations."—p. 75.

An excursion to Maryland and Virginia being planned for the succeeding autumn, Collinson sends him particular instructions, and letters of introduction, "which letters come to J. Logan to save thee postage," commending him to his friends in those parts, to *Robert Gover*, *Col. Custis*, *Col. Boyd*, *Isham Randolph*, &c. Anxious that his protégé should make a favorable impression, he adds a few words of exhortation as to dress.

"One thing I must desire of thee, and do insist that thee oblige me therein: that thou make up that drugget clothes, to go to Virginia in, and not appear to disgrace thyself or me; for though I should not esteem thee the less, to come to me in what dress thou will,—yet these Virginians are a very gentle, well-dressed people—and look, perhaps, more at a man's outside than his inside. For these and other reasons, pray go very clean, neat, and handsomely dressed, to Virginia. Never mind thy clothes : I will send more another year."—p. 89.

The following postscript to a later letter leads one to infer that the plant collector hardly needed this advice.

"One thing I forgot to mention before, and what very much surprises me, to find thee, who art a philosopher, prouder than I am. My cap, it is true, had a small hole or two on the border; but the lining was new. Instead of giving it away, I wish thee had sent it to me back again. It would have served me two or three years, to have worn in the country, in rainy weather."—p. 114.

The following reminds us of a similar and equally explicit letter of Collinson's to Linnæus himself, published in the Linnæan Correspondence.

"The *Systema Naturæ* is a curious performance, for a young man [Linnæus;] but his coining a set of new names for plants tends but to embarrass and perplex the study of botany. As to his system, on which they are founded, botanists are not agreed about it. Very few like it. Be that as it will, he is certainly a very ingenious man, and a great naturalist. As these were not in our mother tongue, was the only reason I did not send them to thee. I hope not to be forgetful for the future."—p. 106.

It would seem that Collinson was the first to send the American *Ginseng* to China.

"I sent some Ginseng roots to China. If they sell well, a good profitable trade may be carried on. In the mean time sow the seed, and raise a stalk to furnish my friend, when he returns. Keep that a secret, and raise what thee canst: for I have an opinion it will turn to account, if my friend manages it rightly."—p. 125.

"I am well assured it will prove a profitable commodity to China, who value it above anything. I have compared yours with the Chinese, and find them in all respects the same. Your proprietor was so kind to send me a considerable parcel, and I have trusted a particular friend with it, to carry to China, to see how they approve of it, and to find what price it bears; but my friend is under promise not to discover that it is *American;* for if they know that, they are so fanciful it may not be so good as their own."—p. 127.

The next year brings Bartram another remittance.

"I could not omit sending thee the above-mentioned £20 10*s*. by Captain Wright, who is a most obliging man, and he knows thee, and perhaps may give the carriage, though I shall not receive the money this twelvemonth, nay, I have now some standing two years; for it is very hard getting money of great people, though I give them my labor and pains into the bargain. They are glad of the cargo, but are apt to forget all the rest. They give good words, but that will not always do; but for thy sake, and if it will but contribute to keep thee in thy circumstances, I gladly will do all, and much more, if it will but be of service to thee, and encourage thy ingenuity. * * *

"It is very entertaining to survey the great variety of mosses that there is with you, as well as with us. I have sent mine down to the Doctor, who admires at thy diligence. He observes paper is scanty, so has desired me to send thee half a ream of writing paper, which comes in a parcel per Captain Wright, with some paper for specimens.

"The books, Tournefort, are a present from Lord Petre, which I hope will make thee easy."—pp. 140, 141.

Lord Petre was one of the most enterprising and successful planters of that day. How largely Bartram's collections enabled him to raise American trees, may be learned from the following extract.

"The trees and shrubs raised from thy first seeds, are grown to great maturity. Last year Lord Petre planted out about ten thousand Americans, which, being at the same time mixed with about twenty thousand Europeans, and some Asians, make a very beautiful appearance;—great art and skill being shown in consulting every one's particular growth, and the well blending the variety of greens. Dark green being a great foil to lighter ones, and bluish green to yellow ones, and those trees that have their bark and back of their leaves of white, or silver, make a beautiful contrast with the others.

"The whole is planted in thickets and clumps, and with these mixtures are perfectly picturesque, and have a delightful effect. This will just give thee a faint idea of the method Lord Petre plants in, which has not been so happily executed by any: and, indeed, they want the materials, whilst his lordship has them in plenty.

"His nursery being fully stocked with flowering shrubs, of all sorts that can be procured,—with these, he borders the outskirts of all his plantations; and he continues annually, raising from seed, and layering, budding, grafting—that twenty thousand trees are hardly to be missed out of his nurseries."—p. 145.

The next year, however, an affecting letter of Collinson's announces to Bartram the death of his noble patron, of the small pox, in the thirtieth year of his age; and, with a fine tribute to his memory, adds:—"All our schemes are broke. Send no seeds for him nor the Duke of Norfolk; for now he that gave motion is motionless;—all is at an end." Other subscribers, however, were found, and Bartram's operations were continued. In the following extract, for Owegos read *Oswego*. Bartram had made a journey through the northern part of Pennsylvania and the country of the Five Nations to Oswego, an account of which was soon after published.

"I thank thee for thy curious present of thy map, and thy draught of the fall of the river Owegos [?]. I was really both delighted and surprised to see it so naturally done,—and at thy ingenuity in the performance. Upon my word, friend John, I can't help admiring thy abilities in so many instances. I shall be sparing to say what more I think. A man of thy prudence will place this to a right account, to encourage thee to proceed gently in these curious things, which belong to a man of leisure, and not to a man of business. The main chance must be minded. Many an ingenious man has lost himself for want of this regard,—by devoting too much of his time to these matters. A hint thee will take in friendship: thy obliging, grateful disposition, may carry thee too far. I am glad, and delight much in all these things—none more: but then I would not purchase them at the expense of my friend's precious time—to the detriment of his interest, and business (now, dear John, take me right).—I showed them to Sir Hans. He was much pleased. Lord Petre deservedly much admires them; and, indeed, does every one that sees them, when they are told who was the performer.

"All this is writ by rote, or from memory, for I dare not, nay, I cannot look into thy letters; for I have no time to add more, but to tell thee—in the trunk of the Library Company, thee'll find a suit of clothes for thyself. This may serve to protect thy outward man,—being a drugget coat, black waistcoat, and shagg breeches. And now, that thou may see that I am not thoughtless of thy better part, I send thee R. Barclay's *Apology* to replenish thy inward man. So farewell. Success attend thee in all thy expeditions. The first leisure, will consider all thy letters. They are all carefully laid up. The chrysalises are all in fine order. I am in hopes of some new beauties. I can now add no more, but that I am thine.

P. Collinson."—pp. 152, 153.

Bartram was born, educated, and married in the Society of Friends, and was, we believe, still a member of the Society at this date (1742). His letters show a very independent and philosophizing turn of mind, and we may have occasion to cite hereafter some unquakerly remarks of his on the subject of war. It is hardly to be wondered at, therefore, "that the views which he entertained had led to his exclusion from the Society so early as the year 1758." To take fully the point of his decidedly ungracious reception of the Quaker's text-book which the London Friend had so kindly presented, it should be mentioned that Bartram had asked Collinson to purchase for him Tournefort, and other botanical works; to which his considerate correspondent had replied that they were rather costly.—"Now I shall be so friendly to tell thee that I think this is too much to lay out. Besides, now that thee has got Parkinson and Miller, I would not have thee puzzle thyself with others; for they contain the ancient and modern knowledge of botany. Remember Solomon's advice: in reading (?) of many books there is no end." Still the good Collinson always contrived in the end to have all these books sent to him, as presents.

"July the 6th, 1742.

"A few hours past, I received thy letters of March the 3d, and 20th, and April the 25th, 1742.

"Yesterday the ship arrived, which our dear friend Captain Wright sailed in from London, but alas! hath left her captain asleep in Neptune's bosom: and now, such a mortal sickness is on board, that she is ordered to ride quarantine below the town. No goods can be got off.

"I heartily thank Sir Hans Sloane for his kind remembrance of me. I long to see his History; and particularly M. Catesby's books, to see what birds he hath figured, before I set out next week for a journey along our sea-coast, where I believe there are many birds which he omitted to draw—which I shall be very particular to observe their dimensions, shape and colors, if I can compel them, by the charms of sulphur and nitre and lead, to let me dispose of them as I think most suitable.

"I shall endeavor to procure Lady Petre a humming-bird's nest, and eggs, as soon as possible. I have not heard of any being found this year. They commonly build their nest upright upon a limb of a tree, and a little shake with the fall of the tree separates them. The fine, downy composition, is gathered from the stalks of our fern. The bladders of balm, which I sent thee, I gathered on the Balm of Gilead tree, on the Katskill Mountain,—a delicate, fragrant liquor, as clear as water.

"I design, next month, to go myself and gather some seed for you, which I hope will be as much pleasure to you, as fatigue and charge to me to get them. There is no more trust in our Americans, than curiosity. Colonel Salisbury, who lives near them, sent me last winter, a very loving letter, affirming he did what he could to procure them, leaving orders, when he went to York, to gather them; but at his return, there is none gathered. He sent a man on purpose to the mountains, to gather them; but he said the birds had picked all the seed out, being very fond of them.

"I am glad my map and draught were acceptable, although clumsily done,—having neither proper instruments nor convenient time; being, most of them, in part of a first day, or by candle-light,—having no whole original but nature, nor time to take a copy,—being hurried in gathering or packing of seeds.

"I am greatly obliged to thee for thy necessary present of a suit of clothes, which just came in the right time; and Barclay's *Apology*, I shall take care of, for thy sake. It answers thy advice, much better than if thee had sent me one of Natural History, or Botany, which I should have spent ten times the hours in reading of, while I might have labored for the maintenance of my family. Indeed, I have little respect to *apologies* and disputes about the ceremonial parts of religion, which often introduce animosities, confusion, and disorders in the mind —and sometimes body too; but, dear Peter, let us worship the one Almighty Power, in sincerity of heart, with resignation to His divine will,—doing to others as we would have them do to us, if we were in their circumstances. Living in love and innocency, we may die in hope."—pp. 158, 159.

Bartram, at Collinson's request, had gathered some mosses, &c., for Dillenius, who in turn sent him a copy of his *Historia Muscorum.* This is acknowledged by Bartram, in the following extract, and also to Dillenius himself, in a letter printed on pp. 310–11.

"I received thy kind letter of June the 16th, and the seeds and book of Doctor Dillenius, last night. I take it to be the completest of that kind that ever was wrote; for we don't read that Solomon wrote of any plants of humbler growth than the hyssop: so I conclude he knew as little of mosses, as he did of the plants that grew beyond Mount Lebanon, or in America."—p. 161.

The subjoined extracts are from a letter of Collinson, in 1743–4.

"Friend JOHN:—The prices of microscopes are advanced to a guinea; so I have only sent thee one, for thyself, and desire thy acceptance of it, with a book. * * At present, can give thee no assurance of any new contributors, only the Duke of Richmond and P. Miller continue,—who love new things; but whether so small a subscription will countervail thy going among the *saints*, in New England, I must submit to thy consideration. * * * Dr. Dillenius has writ thee a letter;—is greatly delighted with the last seeds, they are so good; says that thou art the only man that ever did things to the purpose. The curiosities for Dr. Gronovius are gone for Holland, with the specimens. I have writ both to him and Linnæus, not to forget the pains and travel of indefatigable John Bartram,—but stick a feather in his cap, who is as deserving as the rest."—p. 171.

That is, to keep in mind a genus *Bartramia.* The genus dedicated to him by Linnæus, in the *Flora Zeylanica,* however, proved to be only a species of Triumfetta; and the name was subsequently given by Hedwig to a fine genus of mosses.

Bartram and Collinson occasionally make themselves merry at the expense of Dr. Witt, of Germantown, a remarkable character in his day, who dabbled in divination as well as botany, and was a little touched with quasi-Swedenborgianism, as would seem from the first part of the following extract. The latter part testifies to Bartram's accuracy of observation about the pine-cones.

"I received the nails, calico, Russia linen, and the clothes for my boys: all which are very good and well chosen, and give great satisfaction. The only thing that gives me any uneasiness, is, that thee hath sent more than what is my due.

"Now, though oracles be ceased, and thee hath not the spirit of divination,—yet, according to our friend Doctor Witt, we friends that love one another sincerely, may, by an extraordinary spirit of sympathy, not only know each other's desires, but may have a spiritual conversation at great distances one from another. Now, if this be truly so,—if I love thee sincerely—and thy love and friendship be so to me—thee must have a spiritual feeling and sense of what particular sorts of things will give satisfaction; and doth not thy actions make it manifest? for, what I send to thee for, thee hath chosen of just such sorts and colors as I wanted. Nay, as my wife and I are one, so she is initiated into this spiritual union; for thee has sent her a piece of calico so directly to her mind, that she saith that if she had been there herself, she could not have pleased her fancy better. * * *

"In opening these fine cones of Cluster Pine, I observed how close the scales adhered, which is contrary to all our pines and firs (except one species of the three-leaved pine); which, before they are well dried, spring open and shed all the seed out, which makes them the difficultest to gather. One may, in the beginning of the week, see the cones green—and before the latter end, all the seed that is good will be shed out, especially the five-leaved, which you are so fond of—and which it is not possible for me to gather any great quantities thereof, as I wrote to thee, last year. I design to get what I can, yearly; but, as I can't be in three or four hundred distant places in three or four days' time, I can't procure great quantities; and if I depend upon others' assistance, I am sure of being deceived.

"As our friend Miller seems to question my account of our pines, I now tell thee I generally take care to speak truth—even to those that I think will bestow no more pains of examination, than to tell me it is not so,—to whom silence suits better than arguments—as ignorance doth to their capacity; but, as I have a great opinion of Miller's learning and judgment, I am engaged in duty and friendship to inform him the best I can, at present.

"All our pine cones are two summers and one winter, from their first appearance to their perfecting and casting their seed, but this one species,—which open not till the second or third year after they seem perfectly ripe. I have been much surprised at observing these trees have upon one branch all the cones of three, four, or five years' growth, at once."—pp. 174, 175.

An allusion to Franklin's discovery occurs in a letter from Collinson, dated January 11th, 1753, while writing of the great difference between the climate of England and North America.

"I have heard thunder but once this year, and that at a distance, whilst you have had it so terrible all over your continent,—as our friend Clayton writes me from Virginia; and we have had scarcely sufficient to make our ingenious friend Franklin's experiment. * * I gathered such a nosegay on Christmas day, would have delighted thee to have seen it. In England, vegetation may be said never to cease; for the spring flowers tread so on the heels of the autumn flowers, that the ring is carried on without intermission."—p. 189.

Bartram is apt to complain, whenever his letters and commissions are not very promptly attended to. This calls forth from Collinson the following mild rejoinder.

"If my friend John Bartram knew better my affairs, my situation in life, my public business, my many engagements and incumbrances,—instead of being in a pet, that I answer not the letter he sends by one ship by the next that sails—he would wonder I do so well as I do, though he thinks it so ill. * * He should never suspect his friend, until he has better foundation for so doing. To serve him, I often neglect my own business. His surmises are well meant; yet they arise from want of experience and not knowing me, and the share I have in the busy world, so well as I could wish; then he would not think me so bad a correspondent. And I dare venture, now I have given him these friendly hints, he will not think me so again; but continue his friendly and informing, as well as his entertaining correspondence. * * I thought he had known me better than to think anything he sends me either lost or neglected. * * * *

"The cranberry thrives wonderfully, and is in blossom; every way agreeing with ours, but much larger. * * *

"Pray give my thanks to Moses, for his two letters. In the box, with the other things, I have sent two fine Cedar of Lebanon cones, just come from thence. * * * * *

"There is a little token, in a box, for Billy, whose pretty performance pleases me much.

"Thy account of the frogs is very humorous; but would it not be more so, to import a cargo of them? And had I a park, or place inclosed, I would wish it. But as it is, strolling people and boys would destroy them. A bull-frog would surprise the whole village; but then it would be certainly killed."—pp. 192, 193.

On more than one occasion, Bartram alludes to a theory in respect to petrifactions and the formation of limestone, which he had communicated to Dr. Fothergill. Collinson seems not to have quite comprehended it; but Bartram writes,—"My dear worthy friend, thee can't bang me out of the notion that limestone and marble were originally mud, impregnated by a marine salt, which I take to be the original of all our terrestrial soils." p. 210. And Collinson afterwards writes, "What shall we say to the strata abounding with fossil sea-shells, &c.? Very probably, as thou conceives, the sea flowed higher, or once overflowed all."—p. 237.

Quite characteristic are Bartram's remarks in the subjoined extract from a letter in January, 1757.

"Many birds, in their migrations, are observed to go in flocks,—as the geese, brants, pigeons, and blackbirds; others flutter and hop about from tree to tree, or upon the ground, feeding backwards and forwards, interspersed so that their progressive movement is not commonly observed. Our blue or rather ash-colored, great herons, and the white ones, do not observe a direct progression, but follow the banks of rivers—sometimes flying from one side to the other, sometimes a little backwards, but generally northward, until all places be supplied sufficiently where there is conveniency of food; for when some arrive at a particular place, and find as many there before them as can readily find food, some of them move forward, and some stay behind. For all these wild creatures, of one species, generally seem of one community; and rather than quarrel, will move still a farther distance, where there is more plenty of food—like Abraham and Lot; but most of our domestic animals are more like their masters: every one contends for his own dunghill, and is for driving all off that come to encroach upon them."—pp. 211, 212.

Here is a curious letter of Collinson's, p. 229, in which he reproves Bartram for "grumbling and complaining, making no allowances for accidents," &c., and ending: "Really, friend John, complain on. I am now so used to that I shall not mind it for the future. But, as thou canst write diverting and curious observations, in this manner I expect to be entertained for the future, which will always give pleasure to thy old friend, P. Collinson." The very next letter from Bartram, despatched, however, before he could have received his friend's homily, sufficiently illustrates the fault which poor Collinson so amusingly deprecates:

"August the 14th, 1761.

"Dear Peter:—I have just now received two letters that came by the packet.

* * "My Yellow Slipper improves well; but the White declines. '*Send double boxes for Pine and Powel and Williamson.*' Who is this Pine? '*Powel and Eddy desire but half the quantity of walnuts.*' Who is this Eddy? '*But all desire new things; they are tired of old ones.*' Do they think I can make new ones? I have sent them seeds of almost every tree and shrub from Nova Scotia to Carolina; very few are wanting: and from the sea across the continent to the lakes. It's very likely ignorant people may give strange names to tickle your ears withal; but, as I have traveled through most of these provinces, and have specimens sent by the best hands, I know well what grows there. Indeed, I have not yet been at the Ohio, but have many specimens from there. But in about two weeks I hope to set out to search myself, if the barbarous Indians don't hinder me (and if I die a martyr to botany, God's will be done;—His will be done in all things). They domineer, threaten, and steal most of the best horses they can. None could have worse luck than I with your roots sent last fall and this spring."—pp. 231, 232.

The following touches upon politics.

"London, May 22d, 1762.

"Whilst my dear John is in a melancholy mood for the loss of Pitt, I keep myself in equal poise; but the success *in one scale*, and his two rash French expeditions, on their coasts, *in the other*, in which he wantonly sacrificed so many brave Englishmen, to answer no purpose but his vain-glory. Had they been sent *then* to Martinico, some millions had been the difference to England. If we consider the number of our ships taken, and their rich cargoes, the men useless, and the vast produce of that island kept from us, so all things put together (for this is a short sketch), I don't find any cause to lament his abdication. We go on full as well without him. So prithee, my dear John, revive and don't sink, and be lost in doleful dumps under so terrible an event, which portends no harm that I can see; for we have a brave King, and good men at the helm. Never fear: we shall keep Canada, and have a good peace; and Pitt is as well pleased with his mercenary pension of £3000 per annum, and a title in reversion; and has cleverly slipped his neck out of the collar, when it most became him to keep in, to serve his country, but he preferred serving himself before it.

"From one melancholy story we come to another;—the loss of so many fine plants, which affects me more than the loss of Pitt.

"It is a fair probation, how far the principles of vegetation may be maintained when removed from a warmer latitude to a colder. Art will assist nature. There are many fine plants that grow on this side the Tropics, if we will bestow a south wall on them, will thrive and flower well in our northern climate.

* * * * * *

"I cannot advise, for I am fearful thy grand expedition to the lakes will be too much to undertake without suitable companions, for accidents may happen in so long a journey. But if it was thy resolution, my advice will come too late. So, my dear John, farewell.

P. Collinson."—pp. 235, 236.

There are three letters from Bartram, written in the autumn of 1763, after his visit to Carolina and Georgia, expressing a strong desire to explore the country of Canada and Louisiana for natural productions, adding, "But this would alarm the Indians to the highest degree. All the discoverers would be exposed to the greatest savage cruelty, the gun, tomahawk, torture, or revengeful devouring jaws. Before this scheme can be executed, the Indians must be subdued, or drove above a thousand miles back. No treaty will make discovery safe."—p. 224. And again—"The most probable and only method to establish a lasting peace with the barbarous Indians is to *bang them stoutly*, and make them sensible that we are men, whom they for many years despised for women. Until then it is only throwing away blood and treasure to make peace with them."—p. 255. And in the same strain is the next letter.

"November 11th, 1763.

"Dear worthy Peter:—I have received my dear friend's letter of August 23d, 1763.

"I think most of our people here look upon all our boasted acquisitions in North America to be titular, and that only of short duration, as the French still claim all one side of the Mississippi, and part of our side. They will draw the chief of their fur trade near them, and will always be setting the Indians against us, suppose we do keep possession of the lakes. But unless we bang the Indians stoutly, and make them fear us, they will never love us, nor keep peace long with us. They are now got so cunning, they will not sell their land, and stand so to their bargain as to let the people live quietly upon it. But when they want goods, it is but rob the traders, steal horses, plunder and insult the back inhabitants, and instead of us calling them to account for their mischief, we sue to them for peace, and give them great presents to kill no more white people for three or four years. By such proceedings, they have us in the greatest contempt, believing they may do us all the mischief they please, and we are ready at any time to buy a peace with them for a few years, under great insults. * *

"The variety of plants and flowers in our southwestern continent, is beyond expression. Is it not, dear Peter, the very palace garden of old Madam *Flora?* Oh! if I could but spend six months on the Ohio, Mississippi, and Florida, in health, I believe I could find more curiosities than the English, French and Spaniards have done in six score of years. But the Indians, instigated by the French, will not let us look at so much as a plant, or tree, in this great British empire."—p. 256.

To all this the benevolent Collinson replies in a more Quakerly way.

"Ridgeway House, December 6, 1763.

"I am here retired, all alone, from the bustle and hurry of the town, meditating on the comforts I enjoy; and whilst the old log is burning, the fire of friendship is blazing—warms my imagination with reflecting on the variety of incidents that hath attended our long and agreeable correspondence. * * * *

"My dear John, thou does not consider the law of right, and doing to others as we would be done unto.

"We, every manner of way, trick, cheat, and abuse these Indians with impunity. They were notoriously jockeyed and cheated out of their land in your province, by a man's walking a track of ground in one day, that was to be purchased of them.

"Your Governor promised the Indians if they would not join the French, that when the war was over, our troops should withdraw from Pittsburg. They sent to claim his promise but were shuffled off. They resented it, as that fortress was situated on their hunting country.

"I could fill this letter with our arbitrary proceedings, all the colonies through; with our arbitrary, illegal taking their lands from them, making them drunk, and cheating them of their property. As their merciless, barbarous methods of revenge and resentment are so well known, our people should be more careful how they provoke them.

"Let a person of power come and take five or ten acres of my friend John's land from him, and give him half price, or no price for it, how easy and resigned he would be, and tamely submit to such usage! But if an *Indian* resents it in his way, instead of doing him justice, and making peace with him, nothing but fire and faggot will do with my friend John! He does not search into the bottom of these insurrections. They are smothered up, because we are the aggressors. But see my two *proposals*, in the October Gentleman's Magazine, for a peace with the Indians.

"My dear John, I am glad thou art so happily recovered from that cruel complaint; and that our good Colonel escaped those terrible fellows. I hope such prudent measures will be taken as will put a stop to their ravages, and establish a lasting peace.

"The peace that thou art so merry with, in your mock mourning, is only glorious by comparison; I mean by comparing it with that peace that Pitt would have made (but thanks to our enemies could not). Then you must have been thankful to him and the French, that they would allow you to keep your own narrow strip of land; but now your bounds are so extensively enlarged, how ungrateful! how unthankful you are! for ever grumbling, never pleased. I refer thee to the preliminary of Pitt's peace, and Bute's. Facts speak louder than faction. We all know here what Pitt's peace would have been, and what Bute's is. * * * * * *

"What a glorious scene is opened in that rich country about Pensacola—if that despised country is worthy thy visitation. But because Pitt did not get it, thou canst not venture there on any pretence! All beyond the Carolinas is forbidden ground. They are none of thy darling Pitt's acquisition!

"But thy son John may go with a good grace. I am glad to find the spirit of Elijah rests upon him. * * *

"I hope what I have writ will be read with candor. Our long friendship will allow us to rally one another, and crack a joke without offence, as none was intended by thy sincere friend,

P. Collinson."—pp. 257–259.

Again. "I don't wonder they should be jealous of the invasion of their property. Every man is tenacious of his native rights; and if you invade their rights you must take the consequences. Let those be well *banged*,—I may say well *hanged*—that by their unjust proceedings provoked the Indians to hostilities, knowing beforehand their cruel resentments."—p. 260.

In 1765, when in his sixty-sixth year, Bartram was appointed the King's Botanist in America, to explore the newly acquired country of Florida, &c. The appointment was announced by Collinson, in a letter dated April 9th, 1765.

"I have the pleasure to inform my good friend, that my repeated solicitations have not been in vain; for this day I received certain intelligence from our gracious King, that he had appointed thee his botanist, with a salary of fifty pounds a year; and in pursuance thereof, I received thy first half-year's payment of thy salary, being twenty-five pounds to Lady day last, which I have carried to thy account.

"Now, dear John, thy wishes are in some degree accomplished, to range over Georgia and the Floridas. As this is a great work, and must be accomplished by degrees, it must be left to thy own judgment how to proceed."—p. 268.

"John, thou knows nothing what it is to solicit at court any favor; nay, though it is for their own interest, they are so taken up with public affairs, little things slip through their fingers. For all I can do, I cannot get thee letters of recommendation to any of the Governors.

"All I can at present do, is, our good friend Ellis, who is appointed to an office in the Floridas, has writ to the Governors in thy favor. I send one here enclosed, and will send the other by next ship. * * So thou must make the best of it, and do what seems most agreeable to thy own inclination. Thou may think the appointment not enough. I did not expect any thing. So thou may use it, or refuse it, as thou likes best, or search as far as the salary will go to support it. In this case, I cannot advise thee.

"As thou grows in years, thou will do well to consider if thy present constitution and habit of body can undergo the fatigue of such expeditions. * * * * *

"Our good friend B. Franklin, grows fat and jolly. There is hope of accommodation."—pp. 269, 270. * * *

> Next, "It was highly acceptable to me to hear of my dear John's safe arrival in Carolina, and to find his botanic genius began to exert itself in new discoveries. I wish thou may temper thy zeal with prudence, but I do not think it an instance of it when thou and Mrs. Lamboll rambled in the intense heat of a midday sun. Perhaps it was to procure thee a seasoning."—p. 270.
>
> "Dr. Solander is a strange, idle man. I cannot get thy spring specimens from him, is the reason thou hears nothing from me about them."—p. 271.

But there is no room to continue these extracts, nor to detail the misfortunes of Billy, (William Bartram,) who would be a planter upon the St. John's River, and so get into trouble; nor to advert to some curious bits of early information of "some vast creatures, with the long teeth or tusks of elephants, but with great grinders, belonging to some animal not yet known."

Collinson's last letter to John Bartram is dated July 6th, 1768. There is one to his son, Wm. Bartram, relating his continued exertions for his benefit, dated the 18th of the same month; and he died on the 11th of August, in the 75th year of his age. Bartram himself nearly reached his 79th year, and died, as Dr. Darlington has ascertained, on the 22d of September, 1777.

There is a correspondence with Dr. Fothergill, beginning in 1744, and continued to 1774. This distinguished physician and most benevolent man, took a lively interest in the Bartrams, father and son, especially after the decease of Collinson. A single extract from a letter of his, in 1769, has some interest from its mention of a name afterwards so distinguished.

> "This, perhaps, will be delivered by *Dr. Rush*, a young man, who has employed his time with great diligence and success in prosecuting his studies here; who has led a blameless life, so far as I know; and it seems but just that those who have endeavored to deserve a good character, should have it when it may be of use to them."—p. 341.

Two short letters to Linnæus are printed from Bartram's draughts, one of which refers to a letter recently received from the Swedish botanist. "The letters from Linnæus to Bartram are all missing."

In one of those addressed to the Rev. Jared Eliot, of Killingworth, Connecticut, Bartram gives him a detailed account of his mode of splitting rocks, even seventeen feet long, with wedges;—in the very manner now practiced.

There are few letters from Franklin, between 1757 and 1777. In one of them, dated January 7, 1769, he sensibly urges Bartram to undertake no more long and dangerous peregrinations, at his advanced age, but to devote his leisure hours to "a work that is much wanted, and which no one besides is so capable of performing—I mean the writing the natural history of our country.

I imagine it would prove profitable to you, and I am sure it would do you honor."—p. 403. Repeating the same advice in a later letter, Franklin adds in the Poor Richard vein:—

> "It is true, many people are fond of accounts of old buildings, monuments, &c.; but there is a number who would be much better pleased with such accounts as you could afford them; and for one I confess, that, if I could find in any Italian travels, a receipt for making Parmesan cheese, it would give me more satisfaction than a transcript of any inscription from any old stone whatever."—p. 403.

The correspondence of Bartram occupying a greater number of pages than was expected, the editor felt obliged to restrict very much his selections from the correspondence of Marshall, the author of *Arbustum Americanum.*

Humphry Marshall, the founder of the second botanic garden in this country, and the author of "the first truly indigenous botanical essay published in this western hemisphere," was born in West Bradford, Chester County, Pennsylvania, on the 10th of October, 1722. His father was a native of Gratton, in Derbyshire, England, who came to Pennsylvania about the year 1697, and settled near Darby, but afterwards removed to the forks of the Brandywine. Humphry, who was the eighth of nine children, "used often to state, that he never went to school a day after he was twelve years of age, and consequently he was instructed only in the rudiments of the plainest English education. He was employed in agricultural labors until he was old enough to be apprenticed to the business of a stone-mason, which trade he followed for a few years, and until his marriage, after which he took charge of his father's farm. In 1764, he built with his own hands a brick addition to the paternal dwelling, when he also erected a green-house adjoining it, "doubtless the first conservatory of the kind ever seen, or thought of, in the county of Chester." From the second story he projected a little observatory, in which to indulge his fondness for astronomical observations. From the letters of his correspondents, the good Dr. Fothergill and Dr. Franklin, we find that the latter ordered a reflecting telescope for Marshall, to which the former added a microscope and a thermometer, and *paid for the whole!* And a later letter from Franklin acknowledges the reception of Marshall's "*observations on the spots of the sun,*" which he communicated to the Royal Society, where they were highly spoken of, and a portion was printed in the *Philosophical Transactions*, vol. 64, p. 194. In 1773, he purchased a tract of land adjoining the site of the present village of Marshallton, where he built, like Bartram, with his own hands the house, of which the editor has given a pictorial representation. At the same time he laid out the botanical garden which he long sustained, and which "soon became the recipient of the most interesting trees and shrubs of our country, together with many curious exotics, and also a numerous collection of herbaceous plants." In 1785, his account of our forest trees and shrubs, a 12mo volume of about 200 pages, was published. He attained the age of 79 years, but with a partial loss of sight during his later years; and died on the 5th of November, 1801. He was born in the Society of Friends, and lived and died an exemplary member of that fraternity.

It was only while engaged in collecting and editing the biographical materials of this interesting volume, that Dr. Darlington ascertained that our two botanical patriarchs were not only men of kindred minds and pursuits, "but that they were actually cousins-german, the sons of two sisters. James Hunt of Kingsessing, in the county of Philadelphia, had the happiness to call those ladies his daughters, and the rare privilege of enumerating two of the earliest and most distinguished botanists of Pennsylvania among his grandchildren." His cousin Bartram probably awakened his enthusiasm for horticulture and botany, and promoted his efforts. Fitly are their names and memorials here associated, and heartily do we acknowledge our obligations to Dr. Darlington for the unwearied editorial labors which have given us the interesting volume that we have now so inadequately noticed,—a volume which every where abounds with curious and important facts for the naturalist and the historian, and which rescues from oblivion so many memorable particulars of the lives and times of our earliest devotees to science.

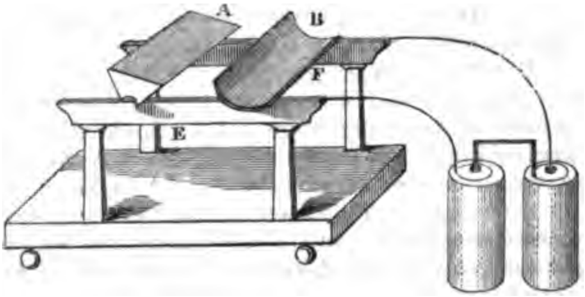
Besides the notes scattered through the work, the editor has given, in a preface, a brief, but very accurate survey of the progress of botany in North America,—of which science he is himself one of the most sedulous and successful votaries. A. Gr.

Art. XV.—*Vibrations of Trevelyan's bars by the Galvanic Current;* by Prof. Chas. G. Page, Washington, D. C.

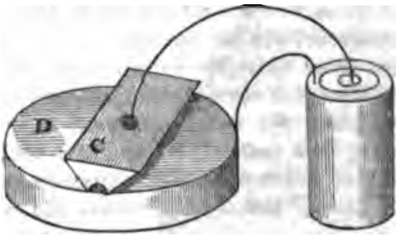
The vibration of Trevelyan's bars by the action of heat is an experiment more interesting than familiar, and one which has been variously and vaguely explained by most authors. It will not be necessary for me to recapitulate the several descriptions and solutions of this phenomenon, as the novel experiment about to be detailed will embrace substantially the whole subject.

About a year since, while exhibiting to a class the vibration of these bars by heat, it became inconvenient to prolong the experiment, as the vibration ceases as soon as the temperature of the bar is somewhat reduced, and I was induced to seek for some method by which the vibratory motion could be produced and continued at pleasure without the trouble of reheating the bars for each trial. After various fruitless efforts I obtained a most beautiful result by using the heating power of a galvanic current. Fig. 1 shews the mode of performing the experiment with the battery. A and B are the two forms usually given to Trevelyan's bars which, when to be vibrated by the action of heat, are made of brass, and weighing from one to two pounds, and after being sufficiently heated, are placed upon a cold block of lead as seen in fig. 2. The two bars may be placed upon the same block though the vibrations are apt to interfere when two are used. When the bars are to vibrate by the galvanic current, they may be of the same size and form as above, and of any kind of metal,—brass or copper or iron, however, seeming to be most convenient. One or both of the bars may be placed at once without reference to temperature upon the stand, as in fig. 1, the bars resting upon metallic rails, E, F, which latter are made to communicate each with the poles of a galvanic battery of some considerable heating power. Two pairs of Daniell's, of Smee's, or of Grove's battery of large size are sufficient. The battery I employ consists of two pairs of Grove's with platinum plates four inches square. The vibration will proceed with great rapidity as long as the galvanic current is sustained.

1.



2.



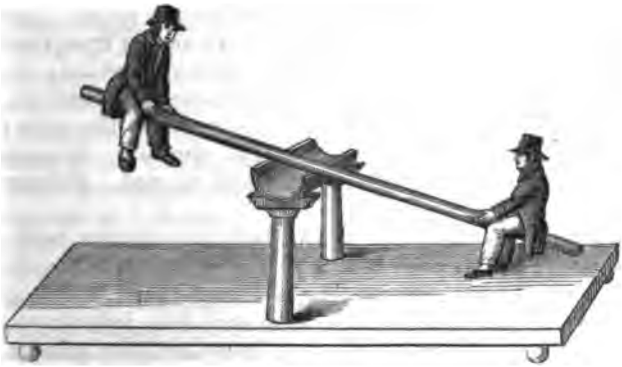
In fig. 2, one pole of the battery is connected with the metallic block and the other pole with mercury in a little cavity in the centre of the vibrating bar. The experiment succeeds much better with the rails, as in fig. 1, and quite a number of bars may be kept in motion by increasing the number of rails and passing the current from one to the other through the bars resting upon them.

The rails are best made of brass wire or a strip of sheet brass, though other metals will answer, the harder metals which do not oxydate readily, however, being preferred. A soft metal like lead is not so favorable to the vibrations in this experiment, although in Trevelyan's experiment lead seems to be almost the only metal that will answer to support the bar which is usually made of brass.

Prof. Graham and other authors have attributed the vibration of Trevelyan's bars to the repulsion between heated bodies, and others have classed the phenomenon with the spheroidal state of heated bodies. I do not consider that any repulsive action is manifested or necessary in either of these cases, nor do I know of any instance in which a repulsion has been proved between heated bodies. It is obvious some other solution is required for this curious phenomenon, and it appears to me that the motion is due to an expansion of the metallic block at the point of contact, and upon this supposition, it appears plainly why a block of lead is required. That is, a metal of low conducting power and high expansibility is necessary, and lead answers these conditions best. In a future communication I will anlayze this matter and explain more fully.

The size of the bars may be very much increased when the galvanic current is employed, and some curious motions are observed when long and large cylinders of metal are used. If they are not exactly balanced, which is almost always the case, they commence a slow rolling back and forth until finally they roll entirely over, and if the rails were made very long they would go on over the whole length. An inclination of the rails is required in this case, but it may be so slight as not to be perceptible to the eye.

3.



If a long rod of some weight be placed across one of the bars, as shown in fig. 3, the vibrations will become longer, and by way of amusement, I have illustrated this with a *galvanic see saw* as it may be termed.

It is well known that where mere contact (without metallic continuity) is made by metals conveying the galvanic current, the metals become most heated at the points of contact, and if the current be frequently broken, the heat at these points is still more augmented. It is for this reason we are able to use various kinds of metals for the experiment, without reference to their conducting powers and expansibilities.

Washington, D. C., Dec. 8d, 1849.

ART. XVI.—*On four new species of Hemiptera of the genera Ploiaria, Chermes, and Aleurodes, and two new Hymenoptera, parasitic in the last named genus;* by S. S. HALDEMAN.

PLOIARIA MACULATA, *Hald.* 1847. Proceed. Acad. Nat. Sc. 3, 151. Brown, darker beneath, above whitish sericeous; head subglobular posteriorly, eyes black and prominent, a transverse impression between them: antennæ and feet annulate with brown and white: mesonotum fulvo-sericeous, with an oblong marginal dark brown macula; base transversely rectilinear between the wings, with a pale medial elongated spine directed backwards between the closed wings: superior wings pale gray covered with whitish reticulations and pale brown maculæ; apex and a larger marginal triangle towards the base, dark brown, divided by pale reticulations, which leave a series of large spots around the apex.—2 lines long. Pennsylvania in June and July: rare. This species is the analogue of the European *P. vagabunda*, to which it bears a close resemblance. The first description was taken from a mutilated specimen.

CHERMES CASTANEÆ. Flavous, thorax, pectus, and eyes black; wings translucent, inner half of the stigma scarcely discolored; 1st and 3d transverse nervure normal; 2d arising from the middle of the 1st and terminating in the normal position; posterior wings without nervures: feet and antennæ pale fuscous. The wingless individuals are entirely flavous, with the eyes rufous. Inhabits both sides of the leaf of the chestnut, forming lines along the midrib, and causing the leaf to curl. Pennsylvania in August and September.

ALEURODES ABUTILONEA. White, body pale flavous, with a tinge of greenish: wings each with a single nervure, the superior ones with two irregular obscure bands across them, and a circular apical spot: eyes black, double upon each side, inferior ones large and prominent: thorax above, with large irregular fuscous spots; abdomen with 3 or 4 transverse lines of the same color: rostrum as long as the head, 2-articulate, apex black: antennæ with the basal articulation robust: feet with short hairs, slender, dimerous. ½ lin. long.

Larva oval, plane above and beneath, elevation about one third the length, periphery vertical; pale flavous, the larger individuals with a conspicuous dark dorsal vitta.

Found upon the lower surface of the leaves of Sida (Abutilon) abutilon, to which the larva is immovably attached. It is sometimes so abundant that there are from 50 to 100 in half an inch square, causing the leaf to curl and die. The perfect insect is very active, walking and flying readily, and leaping from 1 to 1½ inches. It seems nearest allied to A. bifasciatus, *Steph.* When the imago first appears the wings are more translucent and the dark fasciæ are entirely wanting, so that it might be taken for a distinct species.

Burmeister's figure of A. proletella, *Lin.*, exhibits 2 nervures, probably because the wings were in contact when drawn, which, on account of their translucency, would allow the nervures of both to be seen at the same time. Found in Pennsylvania from August to the middle of October.

A. CORNI. Size and general appearance of A. abutilonea: body pale flavous: eyes black; wings pure white, without bands. Pennsylvania in September and October; the larva and imago on the inferior surface of the leaves of Cornus sericea.

Larva flavous, the disc of the larger individuals dark brown: the margin is ciliate with white. A great many are destroyed in the larva state by Amitus corni, *Hald.*, a minute parasitic hymenopterous insect.

AMITUS, (a new genus.) Minute, robust, head transverse, eyes with distinct facets; palpi 0. Antennæ shorter than the body, filiform, geniculate; in the ♂ densely verticillate from the 3d articulation, 10-articulate, scapus somewhat curved, thickened towards its apex, nearly as long as the 3 following; 2d short and thick, *subfusiform*, its apex truncate; 3d as long as the 2d but thinner, and obconic; 4th nearly as long as the 2d and 3d united, robust towards its apex: 5–9 cylindrical and subequal, but becoming shorter towards the apex; apical artic. elongate conical with its apex acute: in the ♀ 8-articulate, shorter than in the male, with the fusiform apical articulation longer, exceeding the 2 preceding ones; the 2d artic. is *robust*, and longer than in the ♂. Thorax robust and elevated, mesonotum with an entire transverse impression. Wings covered with scattered hairs; about as long as the entire body, the greatest width of the anterior ones equalling one-third their length; widely ciliate from the apex to their middle on the posterior side: entirely *without nervures;* anterior ones with the radial margin obtusely concave; posterior ones nearly as long as the anterior ones, and ⅓d of their width, middle of their anterior margin slightly advanced and provided with 2 hooks for attachment to the anterior pair. Abdomen sessile, movable, depressed, convex above and below, subcordate, fully as wide as the thorax, but longer, basal segment composing ⅔ of the whole, besides which there are 4 small segments (♀): ovipositor not exserted. Feet (♂ ♀) slender elongate, pentamerous, posterior femora incrassated, anterior tibiæ with an inferior apical bifid spine curved beneath the basal artic. of the tarsus, which is concave beneath, and armed with a dense pectiniform series of bristles as in *Cinetus*.

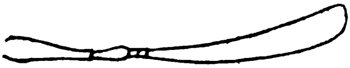
The chief sexual distinction is that (in addition to the scapus) in the ♂ the 2d and 4th articulations of the antennæ are incrassated, and in the ♀ only the 2d, which is moreover one of the longest in the ♀ and one of the shortest in the ♂. Their clothing is also distinct, being long, rigid, and curved forward in the ♂, and short and straight in the ♀. The antennæ have no pedicellus, although, from their translucency at the joints, the round base of the 2d articulation moving in the first, bears some resemblance to one.

The *want of palpi* and the *ciliate wings* would place this genus in Mr. Westwood's subfamily Mymarides, the wings however, are not narrowed, and there is no vestige of a nervure, so that I prefer considering it as a distinct type under the name Amitides. The name, from *α, μιτος* (*a thread*,) is in allusion to the absence of nervures.

A. ALEURODINUS. Polished back, clothed with minute white hairs; a transverse impression above the mouth; antennæ rufous, apex brownish; anterior feet and all the trochanters and tarsi, pale rufous; posterior tarsi, the final joint of the others, and the base of the anterior femora, discolored. ¾ millim. long, or 1¼ to the end of the wings in repose.

Parasitic in the larva of Aleurodes corni, *Hald.*, of which it destroys a great many. I found it with that insect beneath the leaves of Cornus sericea, on the margin of a water course. It leaps, walks and flies with facility, and when touched, simulates death. The antennæ are kept in a constant state of vibration. I have kept them a week or more, living in confinement. The ova (crushed from the ovaries) are fusiform, rounded at one extremity and produced at the other like the neck of a flask.

Two mutilated specimens of another species of parasite were raised with the preceding and imperfectly examined. The color is pale flavous; the wings have a subcostal nerve not quite straight, ending in a short stigmal branch about the middle, the wings in all other respects as in *Amitus;* feet slender and apparently pentamerous; *eyes* black, covered with numerous short *erect bristles*, more distinct than in *Chelonus:* head, thorax and abdomen closely united, thorax large, abdomen with the sides parallel and the apex obtusely rounded, in one specimen (♂ ?) the abdomen seems but half the width of the thorax, and in the other its sides form straight lines with it; *antennæ* (see annexed figure) 5-articulate, shorter than the body, scapus narrowed towards its apex, 2d articulation obconic, 3d and 4th very short, 5th oar-shaped, (whence the generic name,) longer than all the preceding united, widened towards the apex, which is obtusely rounded. It may possibly be parasitic in the larva of the *Amitus* described above, as it is somewhat less in size. I propose to name the genus Eretmocerus, and the species E. corni.



Columbia, Pa., Dec., 1849.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the comparative Cost of making various Voltaic Arrangements;* by Mr. W. S. Ward, (Proc. Brit. Assoc., 1849, in Athen., No. 1142.)—The author stated that a series of calculations founded on data, produced to the Chemical Section at Swansea, showed the efficient power of three generally used forms of battery known as Smee's, Daniell's, and Grove's, would be equal when 100 pairs of Smee's, 55 pairs of Daniell's or 34 pairs of Grove's were used, and that the expense of working such batteries as regards a standard of 60 grains of zinc in each cell per hour, would be about 6*d.*, 7½*d.* and 8*d.* respectively.

This communication led to conversations on the economy of the electric light and electro-magnetic engines, in which Dr. Faraday, Mr. Shaw, Mr. Hunt, Mr. Elkington and other gentlemen joined. Dr. Faraday remarked on the imperfect character of the electric light, and its inapplicability for the purposes of general illumination; all objects appearing dark when the eye was embarrassed by the intensity of the electric arc.—Mr. Shaw and Dr. Percy instanced the magneto-electric machines which are employed at Birmingham for electro-plating, in which the current cost of the motive power—viz., a steam-engine to put the magneto-electric machine in action, was the only working cost.—Mr. Elkington stated that they had never been induced to abandon the voltaic battery which they employed in their manufactory, finding it more economical than the magneto-electrical machine of which he was the patentee. He also stated the remarkable fact that a few drops of the sulphuret of carbon added to the cyanid of silver in the decomposing cell, had the property of precipitating the silver perfectly bright, instead of being granulated so dead as it is when thrown down from the solutions ordinarily employed.

2. *Researches on Wax;* by Benjamin Collins Brodie, (Phil. Mag. for Oct., 1849, p. 244.)—In this Journal for May, 1849, we have given an abstract of the first and second memoirs of the author upon this subject; the present is a continuation of the same investigation, and we can bestow upon it no higher praise, than to say that it is throughout characterized by the ability and conscientious accuracy which commended the previous memoirs to the confidence of chemists. In these

it will be remembered he has described *cerine*, the part of ordinary wax soluble in boiling alcohol; which consists essentially of cerotic acid in a free state. The chinese wax was found to be a compound ether, analogous to spermaceti, which by fusion with potash is resolved into a cerotate and *cerotol*, the latter the alcohol of this series (C_{27}).

The portion of ordinary wax which remains after repeated treatment with boiling alcohol, is generally designated as *myricine*; it is greenish, uncrystalline, and melts at 64° C. Dilute potash has no action upon it, but it is saponified by boiling with a concentrated solution, or fusion with hydrate of potash. The result is a mixture of potash salts with neutral bodies analogous to cerotol; but the separation of these is very difficult and tedious; by decomposing the soap by an acid, and treating the mixture with alcohol, the greater solubility of the acids effects a partial separation. The neutral waxy matter thus obtained, yields by repeated crystallizations from ether, or better from coal naphtha, a highly crystalline body of a satiny lustre and a fixed melting point of 85° C. This substance which constitutes the greater portion of the myricine is a new alcohol which yields by analysis the formula $C_{60} H_{62} O_2$ ($C_{30} H_{62} O$); to this the author gives the name of *melissine*, but for reasons given in speaking of the alcohol of cerotic acid, *melissol* would be preferable. By fusion with potash lime it yields *melissic* acid $C_{60} H_{60} O_4$ ($C_{30} H_{60} O_2$), which resembles the preceding wax acid but fuses at 88°—89° C. The action of chlorine upon melissol, a chlorinized aldehyde, *chlor-melal* (*melissal*); its action with sulphuric acid is also precisely similar to cerotol, a coupled acid being formed. By heat, part distils unchanged, and part is converted into water and a hydrocarbon.

The principal acid resulting from the saponification of myricine, is one which when purified from accompanying acids still more fusible, has a fixed melting point of 62° C. This was found by its analysis and by that of its silver salt, to be the *palmitic* or *ethalic* acid $C_{32} H_{32} O_4$, ($C_{16} H_{32} O_2$).

The distillation of myricine gives a mixture of acids and hydro-carbons; the first part of the distillate consisting almost entirely of acids and the final portions of the hydrocarbons; an odor of butyric acid is observed during the process. The whole product was saponified, and the acids resulting, when purified by repeated crystallization, gave pure palmitic acid.

Among the hydrocarbons is one which from the examination of Ettling, was supposed to be identical with the *paraffine* of Reichenbach and isomeric with olefiant gas. Mr. Brodie's analyses confirm those of Ettling, but the fusing point of the hydro-carbon from wax, when purified by pressing in blotting paper, repeated crystallization from ether, distillation from potassium, and re-crystallization from ether, is raised to 62° C., while the paraffine of Reichenbach melts at 43°·5 C. The analyses of this substance show that it is one of the hydro-carbons represented by $(C_2 H_2)n$, (R in M. Gerhardt's notation,) and as the difference between its fusing point and that of melissol is the same as exists between cerotene and its corresponding alcohol, the author regards this as the hydrocarbon $C_{60} H_{60}$ ($C_{30} H_{60}$) and designates it as *melene* (better *melissene*).

By careful crystallization from ether or a mixture of ether and naphtha, a highly crystalline substance may be obtained from crude myricine, (fusing at 64° C.), which has a melting point of 72° C. The numbers obtained by its combustion correspond very closely with the formula $C_{92}\,H_{92}\,O_4$, which is that of the palmitic ether of melissol; this compound is regarded by the author as the origin of the alcohol and acid obtained by the saponification of myricine.

The other products of the saponification are neutral bodies of lower fusing points than melissol, which by the action of potash and lime yield acids apparently belonging to the type $\mathbf{C}n\,\mathbf{H}\,(C\,H)n\,O_2$, but they have not yet been obtained sufficiently pure to be well characterized. Associated with the palmitic acid is another acid, soft, very soluble and of a low melting point; but its separation from the palmitic acid is very difficult. A specimen of beeswax from Ceylon, fusing at 65°·5 C., was found to contain not cerotic acid, but to possess all the characters of the crude myricine from ordinary wax, yielding by saponification melissol and palmitic acid. T. S. Hunt.

3. *On the Phosphoric Ethers;* by F. Vögeli.—(Compt. Rend. des Trav. de Chemie, March, 1849, p. 85, from Pogg. Anal., t. lxxv, p. 282.) When phosphoric anhydrid is exposed to the vapor of ether, it absorbs it and becomes liquid; this liquid diluted with water and saturated with carbonate of lead, yields a precipitate of phosphate of lead with the sparingly soluble phosphovinate $P\,O_5,\,C_4\,H_5\,O,\,2Pb\,O$; the solution evaporated at a low temperature, yields first laminæ of the latter salt, and finally groups of needles of a new compound, which the author calls biethereophosphate of lead, $PO_5,\,2C_4\,H_5\,O,\,Pb\,O$. This salt fuses at 356°, and at a higher temperature is decomposed into phosphate and phosphovinate of lead, with the evolution of white vapors which condense into a neutral colorless liquid, miscible with ether, alcohol, and even with water. This M. Vögeli regards as the phosphoric ether $PO_5,\,3C_4\,H_5\,O$. Phosphoric anhydrid with absolute alcohol likewise furnishes the two acids; and ether dissolves in syrupy phosphoric acid, but produces only the ordinary phosphovinate.

[These new vinids illustrate beautifully M. Gerhardt's views of the functions of polybasic acids, and his law of basicity.* The phosphoric acid, which is tribasic, has hitherto been known to yield but one compound with alcohol, the phosphovinic acid, which being the product of its reaction with but one equivalent of alcohol, is necessarily bibasic. The new acid containing the elements of two equivalents, is monobasic, while the third compound with three equivalents of the vinic elements is in accordance with the same law, neutral. In relation to phosphoric acid $PH_3\,O_4$ ($P_2\,O_5$, 3HO in the Berzelian notation), these are derived from its reaction with respectively one, two, and three atoms of alcohol, $C_2\,H_6\,O$, and the elimination of a corresponding number of atoms of water. The first acid being already known as the *phosphovinic*, the new acid may be appropriately called the *phosphodivinic*, and the neutral ether, *phosphotrivinid* or *phosphovinid*. Their formulas in the nomenclature of M. Gerhardt will be

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* Précis de Chim. Org., tom. 1er, p. 102. Also this Journal, Sept., 1847, p. 177, and July, 1849, p. 89, *et seq.*

Phosphate, ...	$P(H_3)O_4$
Phosphovinate, . . .	$P(H_2, C_2H_5O)O_4$
Phosphodivinate, . . .	$P(H, 2C_2H_5O)O_4$
Phosphotrivinid, . . .	$P(3C_2H_5O)O_4$.]

T. S. H.

4. *On the Estimation of Nitrous acid;* by H. Schwarz.—(Liebig's Annalen, April, 1849.)—This process is founded on the decomposition of urea by nitrous acid into carbonic acid and nitrogen, noticed by M. Millon, and employed by him in the estimation of urea. (See this Jour., vol. vi, p. 256.)

The well known twin flask apparatus of Will and Fresenius is used; in one flask sulphuric acid is employed as usual—in the other a solution of urea and the nitrite to be analyzed. The apparatus is weighed, sulphuric acid is drawn over, and when the reaction is finished, a sufficient quantity of air is passed through the flasks, and a second weighing gives the loss of CO_2 and N. A loss of 1·00 answers to ·76 of nitrous acid. G. C. Schæffer.

5. *New mode of preparing Nitrogen;* by B. Corenwinder.—(Ann. de Chim. et de Phys., July, 1849.)—No former process for obtaining pure nitrogen is both easy and expeditious. The author employs the remarkable decomposition of nitrite of ammonia by heat, into nitrogen and water—but instead of the salt formally prepared, he makes use of solution of nitrite of potash and hydrochlorate of ammonia. Through a solution of caustic potash, sp. gr. 1·38, is passed nitrous gas (obtained from the reaction of starch 1 pt. and nitric acid 10 pts.) until the product is acid, the solution is then made alkaline by caustic potash, and may be preserved in this state without change. To prepare nitrogen, add to 1 vol. of this solution 3 vols. of very strong solution of hydrochlorate of ammonia, and heat moderately in a small flask—the gas is disengaged very soon, and the decomposition goes on very regularly. To remove the small quantity of ammonia set free by the slight excess of caustic potash, the gas must be passed through water acidulated with sulphuric acid. The nitrogen thus obtained is said to be perfectly pure.

[An economical substitute for the solution of the nitrite prepared as described above, would be found in the nitrite of potash obtained by cautiously heating nitre—in this case there would be sufficient excess of alkali to ensure the stability of the salt in solution.] G. C. S.

6. *New Process for detecting Iodine and Bromine;* by M. A. Reynoso.—(Comptes Rendus, April, 1849.)—To avoid the well known difficulties in the use of chlorine, it is proposed to employ peroxyd of hydrogen to set free the iodine or bromine. A fragment of binoxyd of barium is put into a test tube, and water, hydrochloric acid and starch paste are added—when we wish to test for iodine, as soon as bubbles arise, the liquid to be tested is poured in. In testing for bromine, ether must be substituted for starch paste.

When sulphurets, sulphites, or hyposulphites are present, on account of the absorption of oxygen to form sulphates, &c., more than the usual quantity of peroxyd of hydrogen is required. The sulphate of baryta formed, retards the action unless the mixture is agitated, and in fact it is better in all cases to do so to hasten the evolution of the peroxyd of hydrogen. This process is said to indicate the presence of less than 1 part of iodide of potassium in 100,000 of water. G. C. S.

7. *On the amount of Ammonia contained in the Atmosphere;* by M. Fresenius.—The quantitative determination of the ammonia in the atmosphere, by M. Gräger, gave 0·323 grms. ammonia or 0·938 carb. amm. in 1,000,000 grm. of air. In this determination, the quantity of ammonia already existing in the chlorid of platinum, (used to precipitate the ammonia collected from the air,) was not determined. In an experiment made by Dr. Kemp, 3·68 grms. of ammonia, or 10·37 carbonate of ammonia were obtained. In this case the ammonia was absorbed by a solution of corrosive sublimate, and the quantity estimated from the white precipitate formed.

The very great discrepancies in these experiments, led M. Fresenius to renew the investigations. Two gasometers of 10,000 cub. centimetres (610 cub. in. or about 11 qts.) each, were arranged so as to fill one in the day, the other at night. To each of these there was attached a collecting apparatus of two small flasks connected together and containing dilute hydrochloric acid (1 pt. acid sp. gr. 1·12, and 20 pts. water). For forty days the air was passed through the apparatus. The quantity passed by day was 345,250 cub. cent., (about 12·2 cub. ft.) by night 344,250 cub. cent. (about 12·1 cub. ft.)

The usual precautions in estimating ammonia by chlorid of platinum were observed. The ammonia already existing in the chlorid of platinum was estimated, making use of the same quantity as that employed in the two experiments. The ash of the filters was also very carefully determined.

The air which passed during the day and night gave respectively ·0027 and ·0029 of platinum and ash, from which ·00064 and ·00067 were to be deducted for the ash, and ·00182 for platinum, from determination of ammonia previously existing in the chlorid. The remainders were ·00024 and ·00041 platinum. From this it would result that 1,000,000 grms. of air contain during the day ·098 grm. of ammonia, or ·283 carb. amm.—during the night ·169 ammonia, or ·474 carb. amm.

The author presents these results as an approximation, the quantity of ammonia obtained being too small for accurate results, as any error in weighing or determining the ash, would produce an enormous difference in the results. G. C. S.

8. *On the varieties of Chloroform;* by MM. Soubeiran and Mialhé.—(Journ. de Pharm., July, 1849.)—Chloroform is obtained, as is known, both from common and methylic alcohol (pyroxylic spirits)—the products although generally considered as identical in composition, have such different properties as to render an investigation very desirable.

The methylic chloroform differs from the alcoholic in having an empyreumatic and nauseous odor, a lower specific gravity and a lower boiling point, while its effects upon the system are disagreeable, producing sickness and heaviness in the head. The properties are communicated by a substance which could be separated by repeated rectification over chlorid of calcium, the salt retaining it. By washing with water, an oil was separated, lighter than water, with a boiling point rising from 185° to 271°, and possessing a peculiar and very strong empyreumatic odor. Chlorine is a constituent. Sulphuric acid was found to be the most suitable substance for destroying this impurity of the chloroform, which was then found to be in every respect identical with that obtained from common alcohol.

This impurity amounted in some commercial chloroforms to 6 per cent. Chloroform from common alcohol, furnished a very small quantity of an oil containing chlorine, but differing from that before described.

The authors consider these oils as chlorinated compounds intermediate between chloroform and one of the chlorids of carbon. They also advise that the preparation from methylic alcohol should not be used for inhalation, even that from common alcohol needing a redistillation, as the residue obtained will be found to produce in a remarkable degree headache and giddiness.

The authors have also noticed the curious fact that, when chloroform is poured upon a double filter, part runs through and part is congealed by rapid evaporation, into silky scales. G. C. S.

9. *On the Composition of Shea Butter and Chinese Vegetable Tallow;* by Dr. R. T. Thomson, and Mr. E. T. Wood, (Phil. Mag., May, 1849.)—The Shea butter first noticed by Mungo Park, appears to be very abundant in the regions along the Gambia and Niger, and constitutes one of the principal articles of commerce among the African natives. It is apparently identical with the Galam butter, and is obtained from a species of Bassia. The fruit of this tree is about the size of a pigeon's egg—with a shell about as thin, and "the kernel when new is nearly all butter."

The fat as obtained by crushing the nut and boiling with water, is white with a shade of green—solid at common temperatures, like soft butter at 25°, and a clear liquid oil at 110°.

When saponified, this oil yields a fat acid, which when purified from a small quantity of oleic acid, fuses at 142°, and on analysis proves to be margaric acid.

Chinese vegetable tallow has been long known as derived from the fruit of the Stillingia sebifera, it is hard and white, with a shade of green. It fuses at about 80°. Saponified it yields an acid which softens at 143°, but only becomes quite fluid at 154°. The authors suppose it to be principally margaric acid with a mixture of stearic.

From the apparently unlimited supply, it is suggested that both of these oils might be advantageously employed in soap making. G. C. S.

10. *On the occurrence of Butyric Acid in the Fruits of the Soap tree;* by Dr. von Gorup Besanez, (Journ. für Prakt. Chem. in Chem. Gaz.)—The seeds of the Sapindus saponaria, when pounded and softened in water, are used for washing linen. The peculiar odor led to an examination. On distilling with water combining the distillate with soda, and again distilling with sulphuric acid, a quantity of pure butyric acid was obtained.

The fruit of the tamarind by the same treatment furnished formic and acetic acids, the odor of butyric acid was at the same time developed. As formic acid was also obtained from the fruit of the soap tree, and as tartaric acid exists in both fruits, the author is disposed to think that the butyric, acetic, and formic acids are derived from the oxydation of tartaric acids. With this opinion, as far as butyric acid is concerned, few chemists will agree. G. C. S.

11. *On the preparation of Hyposulphite of Soda;* by M. Faget, (Journ. de Pharm., May, 1849.)—The salt of commerce contains more or less of sulphate; if prepared from *bisulphite* of soda and sulphur, the product contains a large quantity of sulphate and but little hyposulphate. The neutral sulphite should therefore be used. It is best prepared by the following process.

A solution of carbonate of soda is divided into two equal portions, one of them is saturated with sulphurous acid to form the bisulphite, which is then rendered neutral by the second portion. There is present however, an excess of sulphuric acid, owing to the solvent action of the water. This is to be expelled by boiling before adding the sulphur, which may be added afterwards and the solution boiled without risk.

G. C. S.

12. *On the amount of Lime in Lime Water;* by M. Wittstein, (Buchner's Report in Chem. Gaz.)—Of cold water, 732 parts dissolve 1 part of anhydrous lime. The solution in boiling water gave uncertain results—1311, 1495 and 1579 parts of boiling water dissolving 1 of lime.

13. *On the preparation of Succinic acid from Malate of lime;* by Liebig, (Liebig's Ann., April, 1849.)—Piria has shown that impure asparagine in solution ferments and furnishes succinate of ammonia. (See this Journal, vol. vi, p. 421.) Now asparagine is simply the amid of malic acid (malamid). M. Dessaignes with a view to confirm the relation between malic acid and asparagine, devised the following experiment. Neutral malate of lime was exposed under water for about 3 minutes—at the end of which time besides carbonate of lime, mucilaginous matter, &c., there was obtained a crop of crystals which afforded succinic acid. Liebig has found that a fermentation got up with yeast or putrefying cheese, produces the same result in a far shorter time. The following proportions are recommended,—3 pounds crude malate of lime are mixed with 10 lbs. water at 104° and 4 oz. putrid cheese previously rubbed up with water. At 86° to 104° the fermentation is over in five or six days. The heavy granular crystalline deposit formed, is a double salt of succinate and carbonate of lime. This is to be well washed with cold water, and dilute sulphuric acid added until effervescence ceases: an equal amount of dilute sulphuric acid is again added and the whole boiled until the granular form of the deposit disappears. A linen bag is used to separate the gypsum which is washed, and the liquid in them concentrated until a pellicle appears. Concentrated sulphuric acid is then added to decompose some bisuccinate of lime remaining in the succinic acid. Water is next added and the succinic washed out and purified as usual. 3 lbs. of malate of lime furnished 15 to 16 oz. of dazzling white acid.

[In the United States, the cheapest source of malic acid is the common sumach, the salt contained in the heads of this plant is the *acid* malate of lime, which should be neutralized for the preceding process.

It is rather singular that M. Liebig should lay the whole obligation of science for this discovery to the account of M. Dessaignes, while his experiments were undertaken with direct relation to those of Piria which are much older, as shown by the above reference to the pages of this Journal.] G. C. S.

14. *Chemical Analysis of a Calculus from the bladder of a Whale;* by William Keller, M. D., (Proc. Acad. Nat. Sci., Philad., July, 1849, p. 185.)—Whalers report that it is not unusual to find a number of calculi in the bladder of the whale. These calculi are about the size of a hen's egg, on the surface very smooth, and of a white color. On breaking them they are seen to be formed of concentric layers, from the thickness of a sheet of paper to that of a quarter of an inch; the chemical composition throughout being very nearly the same. Mr. Saul Muller and myself took for analysis different layers, and found them of the same composition. The chief constituent of the calculus is the double phosphate of ammonia and magnesia. The quantity of ammonia could not be directly ascertained, passing off at the summer temperature. But it will be seen that the quantity of phosphate of magnesia found, will answer to the quantity of ammonia and water found necessary for the formation of the double phosphate.

The pulverized stone was first exposed to the heat of a water bath, to ascertain the quantity of water; heated with ether and alcohol to find the quantity of fat; then dissolved in nitric acid, the residuum incinerated, the loss was organic matter and uric acid, while the residuum was silicic acid. The quantity of magnesia was ascertained as ammoniaco-magnesian phosphate, the phosphoric acid as phosphate of iron. The carbonic acid, the quantity of which was very small, was found by the apparatus of Will and Fresenius. The rest of the component parts were in such small quantities that they could not be weighed; they were iron, lime, chlorine and soda. The ammonia and water were ascertained by calculation.

Found.		Calculated.	
P_2O_5	27·21	P_2O_5	27·21
Mg O	15·75	Mg G	15·75
Fat	0·39	NH_4	6·08
$\bar{U}$	2·66	HO	44·59
SiO_2	2·18	Fat	0·89
HO	32·17	$\bar{U}$	2·66
CO_2	0·05	SiO_2	2·18
		CO_2	0·05
	80·41		
Traces of NaO, CaO, FeO, Cl.			98·91

15. *On the presence of Fluorine in the Waters of the Firth of Forth, the Firth of Clyde, and the German Ocean;* by G. Wilson, M.D., (Proc. Brit. Assoc., 1849, in Athen., No. 1142.)—In 1846, the author announced the discovery to the Royal Society of Edinburgh, of fluorine as a new element of sea water. He was led to search for it, after observing that fluorid of calcium possesses a certain small but marked solubility in water, which explains its occurrence in springs and rivers, and necessitates its occasional, if not constant presence in the sea. The only specimens of sea water he had examined before this summer, were taken from the Firth of Forth, at Joppa, about three miles from Edinburgh. He obtained the mother-liquor or bittern from the pans of a salt work there, and precipitated it by nitrate of baryta. The precipitate after being washed and dried was warmed with oil of vitriol in a lead basin, cover-

ed with waxed glass having designs on it. The latter were etched in two hours, as deeply as they could have been by fluor-spar treated in the same way, the lines being filled up with the white silica, separated from the glass. The author has recently examined in the same way bittern from the salt-works at Saltcoats, in the Firth of Clyde, but the indications of fluorine were much less distinct than in the waters on the East Coast. On procuring, however, from the same place, the hard crust which collects at the bottom and sides of the boilers used in the evaporation of sea-water, he found no difficulty in detecting fluorine in the deposit. This crust or deposit consists in greater part of sulphate of lime, and of carbonate of lime and of magnesia, but it contains also much chlorid of sodium, and the other soluble salts of sea-water, entangled in its substance. When sulphuric acid, accordingly, is poured on it, it gives off much hydrochloric and carbonic, as well as some hydrofluoric acid, and the latter is thus swept away before it has time to corrode the glass deeply. The author preferred, nevertheless, to use the crust exactly as he got it, that the proof of the presence of fluorine might not be impaired in validity by the possibility of that substance being introduced by the water or re-agents which must have been employed, had the chlorids and carbonates been separated from the crust by a preliminary process. The crust, accordingly, after being dried and powdered, was placed along with oil of vitriol in a lead basin covered by a waxed square of plate glass, with letters traced through the wax. A single charge of the crust and acid corroded the glass very slightly, but by replenishing the basin with successive quantities of these materials, whilst the same plate of engraved glass was used as the cover, he found no difficulty in etching the glass deeply. Operating in this way, he has found fluorine readily in the boiler deposit from the waters of the Firths of Forth and Clyde. It is a less easy matter to subject the waters of the open sea to the requisite concentration, before examination. It occurred to the author, however, that the incrustations which are periodically removed from the boilers of the ocean steamers would serve to determine the question whether fluorine is a general constituent of the sea. He made application, accordingly, at Glasgow and Leith for the deposits in question. It appears, however, that the deep-sea steamers which leave the former have their boilers cleaned out at other ports, so that he has as yet been unsuccessful in procuring crusts from the west coast of Scotland. He has obtained at Leith the crust from the boiler of a steamer called the Isabella Napier, which trades between that port and Wick, so that the greater part of the water consumed as steam by its engines is derived from the German Ocean, although a portion is necessarily obtained from the Firth of Forth. The crust from the boilers of this vessel was treated in the way described, and at once yielded hydrofluoric acid. A single charge, indeed, of the materials marked the glass distinctly, and four charges deeply. We may therefore infer that fluorine is present in the waters of the German Ocean, for different portions of the deposit yielded it readily, and marked glass as deeply as the deposit from the water of the Firth of Forth did, which could not have been the case if the whole crust had not contained fluorine pretty equally diffused through it. From what is known of the comparative uniformity in composition of sea-water, it may safely be inferred that if fluorine be present in the waters of the Firths of Forth and Clyde, and in the German Ocean, it will be found universally present in the sea. Mr. Middleton, before 1846, came to the conclusion that fluorine must be present in sea-water, since it occurred, as he had ascertained, in the shells of marine mollusca. Silliman, junior, without a knowledge of Middleton's views, drew the same inference from its invariable presence in the calcareous corals brought to America by the United States expedition from the Pacific Ocean. The author has found fluorine abundantly present in the teeth of the Walrus, which points to its existence in the Arctic Ocean; and it seems so invariably to associate itself with phosphate of lime, that it may be expected to occur in the bones of all animals marine and terrestrial. The author has found fluorine likewise in kelp from the Shetlands, but much less distinctly than he anticipated. Glass plates were only corroded so far as to show marks when breathed upon. Prof. Voelker, also, was kind enough at the author's request to search for fluorine when analyzing the ashes of specimens of the sea pink (*Statice Armeria*), which had grown close to the sea shore, and contained iodine, and found fluorine in the plant. When all these facts are considered, it is not too much, the author thinks, to urge that fluorine should now take its place among the acknowledged constituents of sea-water. He has entered at length into the consideration of the natural distribution of this element, and into other details connected with it, in a paper in the 'Transactions of the Royal Society of Edinburgh, vol. xvi, part 7, and in a communication made to the Association at its Southampton meeting. The *Statice Armeria* may certainly be added to the list of plants containing fluorine, and so may the *Cochlearia Anglica*, in specimens of which obtained from the Bass Rock, and analyzed in Dr. Wilson's laboratory, Dr. Voelker has also detected this element.

Specimens of etched glass were shown to the Section in illustration of this communication.

Prof. Forchammer confirmed the results of Dr. Wilson. He had examined sea-water from near Copenhagen, and found fluorine in every instance. He had also examined many shells and marine products from various localities, and they all gave the same body—the quantity of which was always greater in sea than in land animals. Mr. Pearsall thought he had detected fluorine in many waters from springs and rivers.

16. *On the Artificial Production of certain Crystallized Minerals, particularly Oxyd of Tin, Oxyd of Titanium, and Quartz;* by M. A. Daubrée, (Compt. Rend., 27th Aug., 1849, 227.)—In a memoir presented in 1841 to the Academy, the author showed that the fluorids appeared to have played an important part in the formation of stanniferous veins. This idea which was then supported only by observations on the structure and composition of deposits of tin, is now confirmed by experiment; for by imitating the process of nature as there explained, he has obtained crystallized oxyd of tin. Not having the apparatus suitable for the production of the stannic fluorid, he employed in its place the chlorid of that metal—the great analogy existing between the fluorids and chlorids permitting this extension of the results obtained on the last to the corresponding fluorids.

The method consists simply in bringing at the same time in a red hot porcelain tube two currents, one of chlorid of tin and one of vapor of water. The oxyd of tin which results from the decomposition of the two vapors, lines the mouth of the tube with mineral crystals. When the perchlorid of tin is introduced, dissolved in a current of dry carbonic acid, (in place of vaporizing the perchlorid by heat alone,) the crystals are obtained of a larger size. The crystals thus obtained are, generally, colorless with the adamantine lustre belonging to the natural mineral, and so hard as readily to scratch glass. Although very small they have the edges and angles perfectly sharp. From the modifications of the crystals, M. Daubrée regards the oxyd of tin as a new example of dimorphism, of which the new form of the artificial mineral is a right rhombic prism, while the natural mineral has the form of a square prism. The artificial crystals always have the two vertical truncating faces greatly extended, so as to present forms much resembling Brookite. The artificial tin crystals have the same longitudinal striæ, parallel to the vertical edges of the primary. The angle of the two truncating faces (133°) is the same as in brookite—(e^3 on $e^3 = 134°$ Levy): thus the artificial rhombic oxyd of tin is isomorphous with brookite.

The natural oxyd of tin has for a long time been recognized as isomorphous with rutile. It appears from these results that the two primary forms of oxyd of tin correspond exactly to the two forms of titanic acid. This isodimorphism furnishes a new and remarkable instance of the geometrical relation which unites the two primal forms of a dimorphous body. The density of the artificial oxyd of tin, which is 6·72, is inferior to that of the square prismatic variety. The density of brookite as compared with rutile, is the same. In two isodimorphous substances, it happens, therefore, that the molecular arrangement of the square prismatic form is more dense than that of the right-rhombic.

Because the artificial oxyd of tin has a form different from that of the native mineral, we are not at liberty to conclude that the two crystalline systems correspond to modes of production which are very different from each other; for in the Oisans and in Switzerland, the same veins and often the same specimens contain at least two of the species of titanic acid, anatase and brookite. The conditions are therefore very similar, which decide the change of molecular equilibrium, producing the two forms of titanic acid.

The vapor of perchlorid of titanium treated by the same methods to which the chlorid of tin was submitted, gave titanic acid in little bristling mammillary masses, the crystalline points perfectly sharp, but of microscopic dimensions. These little crystals have the form of brookite.

The chlorid and fluorid of silicon, treated in the same manner in a porcelain tube, gave unsatisfactory results, but repeating the trial in an earthen retort, and in a crucible protected in an outer crucible and heated to a white heat, he obtained in two experiments a deposit of silica of a vitreous fracture, the mammillary surface of which presented here and there very small crystalline faces, among which are visible triangular faces like those in quartz.

17. *On the origin of the Titaniferous veins of the Alps*, (ibid., 229.)—Many districts of the Alps are known by the beautiful crystals of rutile, anatase and of brookite, which they furnish. The minerals which compose these veins have encrusted previously existing fissures in the same manner as metalliferous veins, properly so called. The mode of occurrence of the titaniferous veins of Saint Gothard and of Oisans, recalls in most particulars, certain small stanniferous veins which the author has already shown elsewhere, to be posterior to the rock which contains them. These veins, however, are injected intimately into the encasing rock. The penetration of crystals of rutile into the interior of crystals of specular iron and of quartz, proves that these three minerals have been precipitated, if not simultaneously, at least under the same conditions. Now the specular iron of these veins recalls by its brilliancy and peculiar form the specular iron of volcanic regions, which as has been shown by Gay Lussac and Mitscherlich, has been produced from the decomposition of chlorid of iron by the vapor of water.

We seem authorized in assigning a similar origin to the specular iron of these titaniferous veins. This first assumption is strengthened if we remember that titanic acid which has been obtained only in an amorphous condition by methods heretofore known, disposes itself in crystals when its chlorid is treated at an elevated temperature by the vapor of water; so it is the same with silicic acid. Thus by a threefold reason are we led to conclude that the minerals of the Alpine titaniferous veins, owe their origin to the decomposition of their respective chlorids and fluorids by the vapor of water. It favors our view that while in the volcanic districts the chlorine has entirely disappeared from the deposits of specular iron; yet in the Alpine veins we still find many evidences of the presence of this agent. It is in fact deposited at the same time with the three species of titanic acid—the fluorids, fluor-spar which is frequent, the fluo-silicates (mica rich in fluorine), the fluo-phosphates (apatite), and lastly the borosilicates (axinite and tourmaline); these each are, so to speak, a complementary product of the fluo-silicates. The apatite of St. Gothard contains 0·002 of hydrochloric acid, showing that chlorine was not wanting during the formation of these veins. Moreover, the presence of crystallized hydrous silicates, as chlorite and various species of zeolites, serves to show that water also bore its part in the filling up of these titaniferous veins.

We arrive, therefore, by proofs of a different character, as well from a study of the deposits as from direct experiment, to the conclusion that rutile, anatase, brookite, specular iron, and at least in part the quartz, which fill up the narrow veins of St. Gothard and Oisans, have been formed from the decomposition of the fluorids of titanium, of silicium, and of iron, associated with fluorids of boron and of phosphorus, and probably also with chlorids of the same bodies. From these several combinations which are volatile and undecomposable by heat alone, (but which are instantly decomposed by the vapor of water,) and from the reactions which have operated upon the encasing rocks, have resulted the fixed substances which now fill the titaniferous veins.

The author then proceeds to amplify the subject by applying the foregoing facts and reasonings to other localities and combinations of minerals.

II. MINERALOGY AND GEOLOGY.

1. *Analysis of Schuylkill Water;* by M. H. Boyé, (Proc. Amer. Assoc., 1848, p. 123.)—The following analysis is published by M. Boyé, with full details of the process he adopted. We here cite his results.*

	Grains in 1 gallon.	In 100 residue.
Alkaline chlorids, ...	0·153	3·75
Alkaline sulphates, ...	0·560	13·74
Alkaline carbonates, ...	0·185	4·53
Carbonate of lime, ...	2·190	53·67
Carbonate of magnesia, . . .	0·484	11·87
Alumina and oxyd of iron (phosphates?)	0·077	1·88
Silica, ...	0·395	9·68
Organic matter, ...	0·036	0·88
Total residue,	4·080	100·00
By a separate experiment, total residue,	4·421	

The above numerical results reduced to 10,000 parts of water, and given, as obtained by analysis, without endeavoring to arrange the ingredients in the manner in which the analyst may consider them as combined in the water, will stand thus:—

	In 10,000 parts.
Sulphuric acid, ...	0·051775
Chlorohydric acid, ...	0·016275
Carbonic acid, ...	0·220195
Potassa and soda, ...	0·076723
Lime, ...	0·211350
Magnesia, ...	0·040095
Alumina and oxyd of iron (phosphates?) .	0·013200
Silica, ...	0·067710
Organic matter, ...	0·006170
	07·03493
Deduct water in chlorohydrates, . . .	0·004022
Total residue in 10,000,	0·699471

The following exhibits a tabular view of the different amounts of solid, fixed, and insoluble residue obtained by Prof. Silliman and M. Boyé—

	BOYÉ. Grains in 1 gallon.	SILLIMAN. Grains in 1 gallon.
Solid residue,	4·080 4·421 } at 250° or over.	5·50 at 212°.
Fixed at a red heat,	3·794 calculated from the above.	4·26 3·69 by direct experiment.
Insoluble in water,	2·896 "	2·145

2. *On Acid and Alkaline Springs;* by Prof. W. B. Rogers, (Proc. Amer. Assoc., 1848, p. 94.)—In this communication after referring to

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* For Prof. B. Silliman's, Jr., examination of the same water, see this Journal, [2], ii, 218.

the principal classes of mineral springs, thermal and of ordinary temperature, and comprehended under the terms acidulous, saline, sulphuretted and chalybeate, Prof. R. entered into a particular account, geological and chemical, of two very distinct classes of springs of frequent occurrence in the Appalachian region, particularly in Virginia and Eastern Tennessee. The one is remarkable for containing a considerable amount of *free sulphuric acid*, along with sulphates of iron and alumina, the other is distinguished by containing a small quantity of *carbonate of soda*, along with carbonate of lime and magnesia, much silica and some carbonic acid and sulphuretted hydrogen.

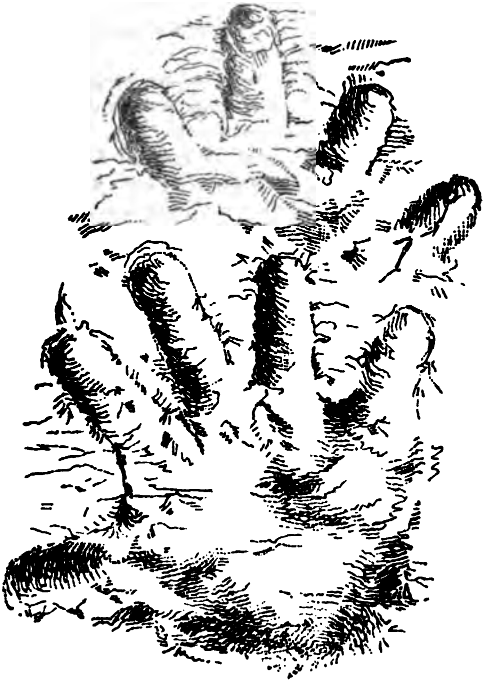
These springs are of very common occurrence in the slates and shales known as the Marcellus, Hamilton, &c., in the New York series, and designated in the nomenclature of the Profs. Rogers, as the post-meridial, older and newer slates and shales respectively. In those parts of these formations, which abound greatly in decomposing bisulphuret of iron, and which are not interstratified with calcareous beds, the springs which occur belong to the former of the two classes. Such, for example, are the celebrated Alum springs and Brinkley's springs near the eastern base of the great Warm Spring mountain in Virginia. At these and similar localities, the crumbling slates are imbued with the products of the decomposed pyrites, and yield to the infiltering waters a portion of free acid, as well as sulphates of iron and alumina. But what is specially remarkable in the composition of these waters, is the fact, that the proportion of free sulphuric acid present, often very greatly exceeds that which the oxydation of the bisulphuret could furnish. This excess Prof. R. proposed to explain in the following way: While the bisulphuret is subject to oxydation, as above mentioned, a part of the sulphates thus formed, reacting with the organic matter, always present in these rocks, gives rise to sulphuretted hydrogen gas. This again, as recently shown by Dumas, in the presence of air and organic matter, gives birth to sulphuric acid—and thus the additional supply of this acid, formed at the expense of the sulphates, will be imparted to the percolating water.

Of the second, or alkaline springs, Prof. R. stated, that they were found in the same general slaty belt with the others, but always in connection with those parts which contain more or less *carbonate of lime*. Instances of these springs are seen in the Grey Sulphur and Dibbrell's springs, as well as many others in Virginia and Tennessee.

The absence of sulphuric acid in these waters, is an obvious consequence of the reaction between the carbonate of lime and the acid in passing into the mass. The same reaction giving rise to the evolution of a great amount of carbonic acid, would, as it were, saturate the pores of the slate with this substance, which, in virtue of its large excess, would have power to decompose the sulphuret of sodium, and perhaps other salts present, and thus give origin to the small amount of carbonate of soda, which imparts alkalinity to these waters. The great proportion of silica, in the solid residuum of these springs, may doubtless be ascribed to the solvent power of the alkaline carbonate.

3. *On Reptilian foot-marks in the gorge of the Sharp Mountain near Pottsville, Pa.;* by Isaac Lea, (Proc. Amer. Phil. Soc., 1849, p. 91.)—The object of this communication is to announce to the Society, that

I have discovered the foot-prints, in bas-relief, of a *reptilian quadruped*, lower in the series than has yet been observed. On the 5th of April last, in the examination of the strata in the gorge of the Sharp Mountain, near Pottsville, Pa., where the Schuylkill breaks through it, a large mass of remarkably fine old red sandstone attracted my attention. Imprinted upon it, I was surprised to find six distinct impressions of foot-marks, in a double row of tracks, each mark being duplicated by the hind foot falling into the impression of the fore foot, but a little more advanced. The strata here are tilted a little over the vertical, and the surface of rock exposed was about twelve feet by six, the whole of which surface was covered with ripple marks and the pits of rain drops, beautifully displayed in the very fine texture of the deep red sandstone.



The six *double impressions* distinctly show, in the two parallel rows formed by the left feet on the one side and the right feet on the other, that the animal had five toes on the fore feet, three of which toes were apparently armed with unguinal appendages. The length of the double impression is four and a quarter inches;* the breadth four inches; the distance apart in the length of the step of the animal thirteen inches; across, from outside to outside, eight inches. The mark of the dragging of the tail is distinct, and occasionally slightly obliterates a small part of the impressions of the foot-marks. The ripple marks are seven to eight inches apart, and very distinct, as well as the pits of the rain drops. These foot-marks assimilate remarkably to those of the recent *Alligator Mississippiensis*, and are certainly somewhat analogous to the *Cheirotherium*.

The geological position of this reptilian quadruped is of great interest, from the fact that no such animal remains have heretofore been discovered so low in the series. Those described by Dr. King, in the great western coal field, are only eight hundred feet below the surface of the coal formation. (No. 13, of Prof. Rogers, the State Geologist.)

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* The figure is rather more than half the natural size of the impression.

The position of the Pottsville "foot-marks" is about 8500 feet below the upper part of the coal formation there, which is 6750 feet thick, according to Prof. Rogers, and they are in the "*red shale*," (his No. 11,) the intermediate siliceous conglomerate (No. 12) being stated by him to be 1031 feet thick at Pottsville. These measurements would bring these foot-marks about seven hundred feet *below the upper surface of the old red sandstone.*

A mass of coal plants exists immediately on the northern face of the heavy conglomerate, here tilted ten degrees over the vertical, and forming the crest and "back-bone" of Sharp Mountain. This conglomerate mass is about one hundred and fifty feet thick at the western side of the road below Pottsville. On the same road side, about 1735 feet from these coal plants, is the face of the rock, tilted slightly over the vertical, and facing the north. It is proper to state, that the limestone of the old red sandstone exists here, about two feet thick, and underlies these "foot-marks" sixty-five feet. I was fortunate enough to obtain these impressions in a large and heavy slab, which is now in my possession.

On the slab there are obscure remains of other organized matter; small spots, with filamentous radiations, and a small bone or reed-like mark, which is difficult to make out.

4. *Gold on the farm of Samuel Elliot, Montgomery County, Md., thirty miles from Baltimore*, (Proc. Amer. Phil. Soc., 1849, p. 85.)—The locality has been known but a few months, and appears to be valuable. Three samples examined at the mint, yielded as follows:—

No. 1 yielded	at the rate of	744 grains	per cwt. of ore, or	$610 00	per ton.
No. 2	"	960	"	787 20	"
No. 3	"	206	"	168 80	"
Average,		636		522	

The quartz which forms the matrix of the gold, crops out amidst a decomposed talcose slate, so that quarrying is very easy. Ores of copper and iron are also present.

Messrs. Bowman & Ebbett, of New York, state that much gold appears to be disseminated throughout the gangue, in so minute a state of division, as to be invisible to the naked eye.

5. *Gold of California*, (from a letter to one of the editors from Rev. C. S. Lyman, dated, San Francisco, Oct. 29th, 1849.)—The gold the past season has turned out much better than was expected. Many rich deposits, in all parts of the mines, have been opened. On the middle fork of the Rio de los Americanos, two men recently dug $28,000 in two months. I saw a portion of it in lumps of the size of hens' eggs and larger. The Mariposa has yielded several similar prizes and so has the Mokelemnes. But for these few fortunate diggers, there are thousands who scarce earn a dollar a day. From the best information I can get, industrious workers have not averaged more than eight or ten dollars a day—some estimate it much lower; multitudes do not pay expenses, particularly clerks, professional men and others unaccustomed to hard work.

The gold has at last been discovered in place—in veins penetrating quartz beds—on the Mokelemnes and in the vicinity of the Mariposa and one or two other places. I have this from gentlemen who have seen the veins and who are reliable witnesses. These veins are of course not worked yet, as it is more profitable to dig the wash gold. One of these veins has been "denounced" (as it is termed) under the Mexican laws, by Mr. Fremont. The working of the innumerable rich veins, which undoubtedly will be opened in the mountains, will constitute an immense and profitable mining business for centuries. I have no fear that the gold, as many imagine, will all be dug out in a year or two.

III. BOTANY AND ZOOLOGY.

1. *Description of a Nut found in Eocene marl;* by EDMUND RUFFIN. (Communicated for this Journal.)—About two months ago, one of my laborers, employed in excavating marl, brought to me the shell of a nut, or large seed, which he had that day found imbedded in the marl, at the depth of about five feet below its upper surface. The marl is eocene—about forty per cent. of it being shelly matter, mostly disintegrated, with enough fine clay to render the mass impervious to water. As it lies low, and is covered naturally by oozing springs, the marl is barely moist, from absorption. Though the composition of the earth, and manifest manner of its original deposition, make it certain that at first the marl was very soft, yet the subsequent addition of materials, and the still later superimposed earth, had by weight so compressed the lower beds, as to make the marl very compact and close. The overlying earth (sand, gravel, and clay) there had been six feet thick. The calcareous marl is eight feet; and this lies on green-sand earth, of great depth, and containing very little shelly or calcareous matter.

As in my long experience in the excavation of marl, and much more extended examination of various marls and their fossils, I had never seen or heard of any such discovery as this, I was careful in scrutinizing the facts stated. The result of the scrutiny was my being perfectly satisfied with the truth of the statement. There could have been no possible object for the negro to attempt a deception. And even if there had been such a design, he could not have provided such means as he here produced, in an unknown if not a unique fossil specimen, in a remarkably good state of preservation. This is the principal and all-sufficient evidence of the good faith of the laborer. He could not possibly have been himself deceived. He had been for years accustomed to work in this marl, and to preserve for me all rare or curious specimens of fossils. At this time, this labor had been in progress for some weeks without intermission; and he had that day (with his assistants) dug several feet into the solid marl before reaching the level of the nut. It was seen partly exposed in a lump of marl just loosened by the hoe from its bed, and was immediately separated. The discoverer did not know the importance of it, and therefore did not preserve the cell or hollow impression of the nut in the lump of marl, which would have been conclusive evidence of the locality of the relic.

When brought to me, the nut had been washed very nearly clean of all the adhering marl. The distension by moisture was very great, (as was learned afterwards by the great shrinking,) and consequently the freshness of appearance, as shown in color, to the touch, and by flexibility, was so much the greater. The perfection of the preservation was indeed wonderful—and scarcely less than I should have expected of any like nut, as an acorn or horse-chestnut, similarly buried for but a few years.

The shell of the nut was almost perfect. The only exceptions were that by compression it was (apparently) flattened; and in being so compressed, a crack had been made and kept open at the upper (or germ) end. The shell while distended by moisture, in color, smoothness of surface, and in partial elasticity, appeared much like old leather, softened by being water-soaked. The color was dark brown, approaching to black. The mark of the stem-attachment, though small, was as distinct as if the nut had been new.

Expecting that the drying of the nut would cause it to crumble and to lose its form, (which however has not occurred,) I made the annexed rough and mechanical, but accurate drawings of the outlines, within thirty hours after the nut was found. Figures 1 and 2 respectively represent the upper and lower compressed sides; and 3, the lower end with the mark of stem-attachment (*a*) held uppermost. How great the distension then was may be seen by comparing the then size with fig. 4, which is the same view as fig. 1, but marked since the thorough drying and shrinking of the shell. The outlines were marked by tracing around the object with a pencil, and using every care to preserve the exact profile of size, as closely as possible. Since drying, the

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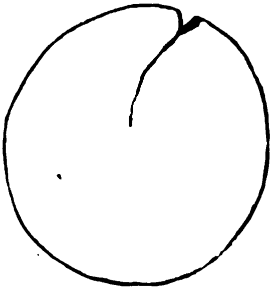

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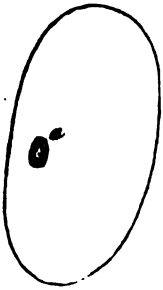

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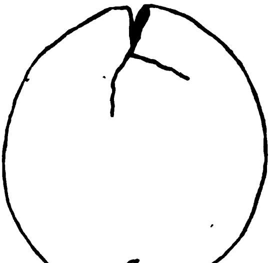

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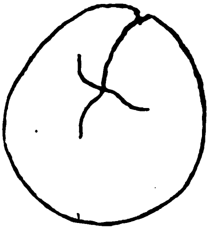

cracks are more extended in length, but less open. The shell is about the twelfth of an inch thick; and now appears more like lignite than any more recent vegetable matter. Of course nothing of the kernel, or true seed, remained. In its place there are some particles of black vegetable matter intermixed with some powdery marl—all which do not near fill the present cavity.

Though my labors in excavating marl of different kinds during many years, and my much more extended personal examinations elsewhere, have given me opportunities rarely enjoyed by others for seeing and gathering fossil specimens from their localities, I make no claim to the character of a scientific investigator of this subject. Therefore, I do not knowon whether (as I infer it is) this nut is an extinct species—or whether the like has been found before.

This marl, bordering the Pamunkey river, has peculiar characteristics, and also has rare value as a manure. The fossil remains are generally much decayed. Among the kinds most common, are shells of *Ostræa sellæformis* and *Cardita planicosta*, either of which sufficiently identifies the marl with the eocene. Some other fossils are either new, or very rare, at least to my observation. Among the most rare is a fragment of a spine of an extinct *Echinus*, which is eight inches long, and more than three quarters of an inch in diameter, where thickest. By comparison of the size with the species of the largest specimens known to me of recent *Echini*, this extinct species must have had a very large body, beset with spines 3 feet long. I have also found smaller fragments of these species in the eocene marls of Coggin's Point, James river, Va., and of the Santee in South Carolina. The *flutings* of the surface of these spines are beautifully regular; so as to seem like delicate artificial carved work.

Lignite is often found in this eocene marl. I have two specimens of impure amber which were found in this kind of marl, though not in my own diggings. One of these was broken from a solid mass which was said by the person who found it to have been nearly a foot in diameter.

Marlbourne, Va., July 4, 1849.

2. *Synopsis Generum Crustaceorum Ordinis* "*Schizopoda*" J. D. Dana elaboratus, et Descriptiones specierum hujus ordinis quæ in Orbis Terrarum circumnavigatione, Carolo Wilkes e Classe Reipublicæ Fœderatæ Duce, auctore lectæ.—(Pars I.)

Ordo II. CRUSTACEA SCHIZOPODA.

Crustacea Macrourorum pullos affiliantia, branchiis sive externis pedes thoracis abdominisve pertinentibus, sive obsoletis; pedibus pluribus birameis palpo valde elongato; maxillipedibus pedes sequentes sæpe assimilantibus.

Tribus I. DIPLOÖPODA.

Pedes thoracis biramei, palpo natatorio, nulli prehensiles. Carapax cephalothoracem plerumque tegens, segmento cephalico non bene discreto.

Subtribus I. MYSIDACEA.

Corpus elongatum, subcylindricum. Basis pedum thoracicorum brevis.

1. *Pedes thoracis branchigeri.*

Fam. I. EUPHAUSIDÆ.—Antennæ primæ birameæ. [In speciebus scrutatis segmentum abdominis posticum barbâ nudâ ad extremitatem utrinque armatum.]

Genus 1. THYSANOPODA, (*M. Edwards*).—Oculi symmetrici, breves. Pedes thoracis quatuordecim, duobus posticis obsoletis branchiis exceptis. Flagella duo antennarum primarum elongata.

Genus 2. EUPHAUSIA, (*Dana*).—Oculi symmetrici, breves. Pedes thoracis non unguiculati, numero duodecim, quatuor posticis obsoletis branchiis exceptis. Flagella duo antennarum primarum elongata. Segmentum abdominis posticum acuminatum.

Genus 3. CYRTOPIA, (*Dana*).—Oculi paulo oblongi, apicem externum obliquè gibbosi, lenticulis totis in gibbositatem versis. Articulus antennarum primarum primus apicem *inferiorem* productus. Segmentum abdominis posticum obtusum aut truncatum.

2. *Pedes thoracis abdominisve non branchigeri.*

Fam. II. MYSIDÆ.—Antennæ primæ birameæ, secundæ laminâ basali instructæ. [Pedes thoracis postici nunquam obsoleti ?]

1. *Pedum rami ambo thoracicorum extremitatem multiarticulati.*

Genus 1. MYSIS, (*Latreille*).—Pedes thoracis duodecim, maxillipedes numero sex. Antennæ primæ flagellis duobus confectæ. Pedes abdominis parvuli, debiles.

2. *Pedum ramus internus thoracicorum non multiarticulatus, bene unguiculatus. Oculi symmetrici.*

Genus 2. PROMYSIS, (*Dana*).—Pedes thoracis duodecim, maxillipedes sex. Antennæ primæ flagellis duobus laminâque oblongâ confectæ. Pedes abdominis oblongi, natatorii, longitudinem fere æqui. [Segmentum abdominis posticum emarginatum vel bilobatum.]

Genus 3. MYSIDIA, (*Dana*).—Pedes thoracis sexdecim, inter sese similes, toti bene palpigeri. Antennæ primæ flagellis duobus laminâque oblongâ confectæ. Pedes abdominis quarti valde elongati, (an discrimen sexualis tantum). [Segmentum abdominis posticum emarginatum vel bilobatum.]

SYN. Themisto, *Goodsir*. Hoc quoque vocabulum generis Amphipodum auctoritatem prius.

Genus 4. SIRIELLA, (*Dana*).—Pedes thoracis sexdecim, toti bene palpigeri, posticorum duodecim ramo pediformi apicem setis brevibus mobilibus (instar digitorum) juxta unguem instructo. Antennæ primæ flagellis duobus confectæ, laminâ carentes. Pedes abdominis toti rudimentarii. [Rostrum brevissimum. Segmentum abdominis posticum apicem rotundatum et spinulis ornatum.]

Genus 5. MYTO, (Kröyer, Tids. N. R. i. 470).—Pedes thoracis quatuordecim, primi secundi tertii quartique palpigeri, quinti sexti septimi simplices. Appendices caudales segmentoque caudali connati, ideoque cauda latè triangulata, margine postico longo. Flagella antennarum primarum non articulata.

3. *Oculi e latere pedicelli externo obliquè spectantes, lenticulis totis parce obliquè versis.*

Genus 6. LOXOPIS, (*Dana*).—Oculi elongati. Antennæ primæ flagellis duobus confectæ, laminâ carentes. Appendices abdominis rudimentarii. [Segmentum abdominis posticum truncatum, vel obtusum, extremitate spinuloso.]*

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* Podopsis, *Thompson*, (Zoological Researches, i, 59, tab. 59, fig. 1,) pullus (forsan mutilatus) incertæ sedis videtur. Oculi longissimi. Antennæ primæ fere obsoletæ; secundæ laminâ instructæ. Pedes duo longissimi, articulo tenui annulato confecti; reliqui breves. Pedes abdominis natatorii.

Sequentes *Furciliæ* et *Calyptopes* forsan pulli Decapodum aut quorundam Schizopodum; generibus jam enumeratis hoc discrepant: *Apex inferior articuli antenna-*

Fam. III. Scletinidæ.—Antennæ primæ simplices, elongatæ; secundæ biramеæ.

Genus 1. Rachitia, (*Dana*).—Carapax anticè acuto-tricuspidatus, post frontem non constrictus—Oculi longi obconici. Segmentum abdominis sextum valde elongatum, [segmentis in specie scrutatâ anticis simul sumtis non longioribus, utroque spinam longam dorsalem gerente.] Antennæ primæ flagello longo tenuissimo confectæ.

Genus 2. Scletina, (*Dana*).—Carapax anticè acuto-tricuspidatus, paulo post frontem instar colli constrictus, deinde ovatus posticè augustans. Oculi prælongi, obconici. Pedes thoracis elongati duodecim, biramei, ramo pediformi 4–5 articulato, altero (palpo) parce setoso; alii pedes breves quatuor, anteriores. Pedes abdominis rudimentarii. [Segmentum abdominis posticum lineare, truncatum vel emarginatum.]

Hæc animalia Luciferibus paulo affines.

3. *Pedes abdominis appendicibus branchiiformibus instructi.*

Fam. IV. Cynthidæ.—Antennæ primæ biramеæ, secundæ laminâ basali instructæ.

Genus Cynthia, (*Thompson*).—Pedes thoracis quatuordecim, biramei; maxillipedes quatuor. Oculi breves symmetrici.

Subtribus II. Amphionacea.*

Corpus depressum, carapace foliaceo. Basis pedum thoracicorum elongatus, palpo a corpore remoto.

Fam. I. Amphionidæ.—Corpus elongatum, abdomine longitudinem mediocri, thorace per carapacem tecto.

Genus Amphion, (*M. Edwards.*)

Fam. II. Phyllosomidæ. Corpus latus et breve, abdomine perbrevi aut rudimentario, thorace per carapacem plerumque non tecto.

Genus Phyllosoma, (*Leach.*)

Tribus II. APLOÖPODA.

Pedes thoracis nec biramei nec prehensiles. Corpus gracile, longum.

Fam. I. Luciferidæ.—Cephalothorax valde elongatus, segmento cephalico (oculos antennasque pertinente) longè attenuato. Oculi tenuiter valdeque elongati.

Genus Lucifer.—Antennæ primæ simplices, secundæ laminâ basali instructæ. Pedes thoracis quatuor postici (ct. xiii, xiv,) obsoleti; octo precedentes (ct. ix, x, xi, xii,) elongati, setigeri; deinde duo antici (ct. viii,) instar maxillipedum flexi. Maxillipedes duo (ct. vii); maxillæ quatuor (ct. v, vi); mandibulæ (ct. iv,) duæ non palpigeræ.

Tribus III. STOMATOPODA.

Os mandibulis duobus maxillisque duobus instructum, membris sequentibus pediformibus. Pedes antici (ct. vi) vergiformes, elongati; 8 sequentes chelati; 6 postici aliis remoti, sæpius bifidi.

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rum primarum primi longè acutèque productus. Animalia scrutata tota immatura, pedibus plus minus rudimentariis.

Gen. Furcilia, (*Dana*).—Carapax plus minus rostratus. Oculi aperti. Pedes abdominis bene natatorii. Antennæ primæ furcatæ ramis (immaturis?) subæquis 1–2 articulatæ; segmentum abdominis posticum truncatum, extremitatem sæpius spinulosum. Animalia in mari alto lecta.

Gen. Calyptopis, (*Dana*).—Carapax non rostratus, oculos omnino tegens. Antennæ primæ biramеæ, ramis (immaturis?) subæquis 1–2 articulatæ. [Segmentum abdominis posticum truncatum, extremitate sæpius spinuloso.]

* Genus *Cuma* cum affinibus Schizopoda et Macroura affiliat. Forsan Ordo "Cumacea" hìc cadit, his dignotus:—Oculi minuti sub carapacem celati: Pedes partim biramei: Appendices caudales prælongi, styliformes et posticè furcati.—M. Edwards, Ann. des Sci. Nat., xiii, 292, Kröyer, Tidsk. iii, 503 and ib. N. R., ii, 128; Goodsir, James. J., xxxiv, 119.

Fam. I. SQUILLIDÆ.—Rostrum carapace per articulationem discretum.

Genus 1. SQUILLA.—Digitus manus maximæ intus spinoso-dentatus. Ramus pedum thoracis sex posticorum minor angustus.

Genus 2. GONODACTYLUS.—Digitus manus maximæ integer. Ramus pedum thoracis sex posticorum minor angustus.

Genus 3. CORONIS.—Ramus pedum thoracis sex posticorum minor lamellatus.

Fam II. ERICHTHIDÆ.—Rostrum carapace non discretum. Branchiæ sæpius rudimentariæ, aut obsoletæ.

Genus 1. SQUILLERICHTHUS.—Erichtho affinis. Digitus manus maximæ intus dentatus.

Genus 2. ERICHTHUS.—Corpus latus. Pars cephalothoracis antica os precedens brevior. Carapax thoracem sæpius omnino tegens. Digitus manus maximæ intus non dentatus.

Genus 3. ALIMA.—Corpus angustus. Pars cephalothoracis antica os precedens longior. Carapax thoracem sæpius non omnino tegens. Digitus manus maximæ intus non dentatus.[*]

Tribus I. DIPLOÖPODA.—Subtribus 1. MYSIDACEA.

Familia 1. EUPHAUSIDÆ.

Genus *Euphausia.*

1. **EUPHAUSIA PELLUCIDA.**—Gracilis. Carapax brevissimè rostratus. Segmenta abdominis margines laterales integra, arcuata. Articulus antennarum primarum primus apicem non productus. Lamina antennarum 2ndarum basalis basi paululo longior. Pedes tenuissimi, articulo ultimo brevissimo, palpo fere triplo breviore quam pes. Segmentum caudale lamellis caudalibus paulo longius, barbis subapicalibus salientibus. Branchiæ posticæ subdigitatæ.—Long. 6‴. Incolorata.

Hab. in mari Pacifico, prope insulas "Kingsmills;" Lecta Ap. 1841.

2. **EUPHAUSIA SPLENDENS.**—Carapax brevissimè rostratus; segmenta abdominis quatuor margines laterales integra, subæquè obtusa. Articulus antennarum 1marum primus apicem productus. Lamina antennarum 2ndarum basalis basin non superans. Pedes tenuissimi, articulis tribus ultimis longitudine subæquis, setis longis breviter plumosis, palpo plus duplo breviore quam ramus alter. Segmentum caudale lamellis caudalibus longius, barbis subapicalibus salientibus. Branchiæ posticæ ramosæ.—Long. 6‴.—Paulo rubescens.

Hab. in mari Atlantico, lat. bor. 1°–2°, long. occ. 17°–18°. Lecta diebus 29, 30, Oct. 1838.

EUPHAUSIA GRACILIS.—Carapax brevissimè rostratus. Segmenta abdominis margines laterales subæquè rotundata. Articulus antennarum 1marum primus apicem parce productus et acutus. Lamina antennarum 2ndarum basalis basin multo superans. Pedes tenuissimi, articulis tribus ultimis longitudine subæquis, setis longiusculis, palpo parvulo, quadruplo breviore quam ramus alter. Segmentum caudale lamellis caudalibus non longius. Branchiæ posticæ ramosæ.—Long. 6‴. Parce rubescens.

Hab. in mari Pacifico, lat. aust. 15½°, long. occ. 148°; lecta die Sept. 1839.

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[*] Longitudo carapacis discrimen Erichthi et Alimæ non semper valet; longitudo partis cephalothoracis os precedentis melius.

Euphausia superba.—Carapax brevissimè acutè rostratus. Segmenta abdominis margines laterales arcuata, integra, sexto non longiore. Articulus antennarum 1marum primus apicem productus et obtusus. Lamina antennarum 2ndarum basalis basi vix brevior. Articulus pedum ultimus pertenuis, penultimo multo brevior. Branchiæ posticæ instar rotæ paulo involutæ, ramis subradiatis, arcuiformibus, ramulis seriatis setiformibus. Segmentum caudale laminâ caudali proximâ paululo brevius.—Long. 2″. Rubra.

Hab. in mari Antarctica, prope long. orient. 150° et lat. aust. 60°.

3. *Eyes of Sapphirina, Corycæus, etc.;* by J. D. Dana.—In a brief description of these genera in the Proceedings of the Academy of Arts and Sciences of Boston, and in this Journal,* a peculiar kind of eye is mentioned, upon which an additional remark is here added. These eyes are simple, and of extremely large size for the animals. The lens is a prolate spheroid, situated internally within the thorax, far remote from the cornea; the cornea is a broad oblate lens, perfectly pellucid and colorless, and connected with the exterior shell. The diameter of each of the latter in many Corycæi is nearly half the breadth of the thorax, and the two stand in the front like a pair of spectacles, huge for the minute animals so provided. In the same animal the prolate lens may be situated as far back nearly, as the middle of the thorax, so that a long space intervenes between it and the cornea. The oblate form of the spectacle-like cornea, (we have called them in Latin, *conspicilla*,) is fitted to compensate for the too great convexity or prolate ellipticity of the lens, and it serves the same purpose as glasses for a near-sighted person.

The genus Sapphirina is closely related to Corycæus, and has the same peculiar eyes. The only mention of these conspicilla, which has been made by any previous author, is to be found in a memoir in F. J. F. Meyenii Obs. Zoolog. in Itin. circum Terram institutas accedunt Guil. Erichsonii et H. Burmeisteri Descript. et Icones Insectorum a Meyenio in ista Expeditione collectorum; from the 16th vol. Nova Acta Cæs. Leop. Car. Nat. Cur., page 156, pl. 27.—The species (probably a true Sapphirina) is called *Carcinium opalinum.* The conspicilla, by a mistake of observation (and it is not the only one in the description and much magnified figure), are spoken of as *dimples* (Grubchen). They are not noticed by Thompson who established the genus Sapphirina. Similar eyes occur in some of the Caligus group, and the writer has established one genus, *Specilligus*, on this ground, which otherwise is identical with Nogagus.

A cornea of lenticular form is by no means peculiar to these species of Crustacea; but they have hitherto been observed only in compound eyes, in which case the lens and cornea are minute and not far distant.

4. *Contributions to Conchology, Nos.* 1–4: *and Monograph of* Stoastoma, *a new genus of new operculated land shells*, by Prof. C. B. Adams, of Amherst College.—Although more than three centuries have elapsed since the West India Islands were first revealed to Europe, it may safely be said that few portions of the world can reward the search of the naturalist with so much that is novel and interesting. This is

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* See last volume, p. 280; also, Proceedings of the Acad. Nat. Sci., Philadelphia, 1845, ii, 285.

more particularly true as regards the department of mollusca, and especially the tribe of air-breathing or land mollusca.

A few only of the larger species of this tribe found their way at an early date into European cabinets, and were described and figured by the conchological writers of the last century. At a later period, through the intercourse between France and the islands dependent on her, French cabinets were enriched with many species from Hayti, Martinique and Gaudaloupe, which adorn the great monograph commenced by Baron Ferussac. The Rev. Lansdowne Guilding, an accomplished English naturalist, resident for many years upon the island of St. Vincents, brought to light the productions of that island; and since then, resident collectors at St. Thomas and at other islands have added something to our knowledge of the land conchology of their vicinities.

The monograph of the genera Helicina and Cyclostoma in Sowerby's Thesaurus Conchyliorum, contained many new West India species. Dr. Gould has described a few species from the island of Cuba, in these and other genera; and Dr. L. Pfeiffer, the author of the admirable Monographia Heliceorum Viventium, also collected many new species from the same island and has published them in Wiegmann's Archiv. A recent hasty visit to the same quarter by Dr. Newcomb, has acquainted us with interesting species from the Isle of Pines, and Mr. Gosse, an English gentleman who visited Jamaica to collect birds, brought home also many new shells which now enrich the Cumingian collection, and have been described by Dr. Pfeiffer.

But the only published work of any extent, which professes to give a detailed account of the conchological fauna of any part of the West Indies, is d'Orbigny's Mollusques de Cuba, forming part of Ramon de la Sagra's history of the Island of Cuba. This work is still incomplete. The first volume of the "Mollusques" was published in Paris in 1841, and is yet little known in this country.

Such are the sources of our knowledge of the West India land shells, aside from that supplied by Prof. Adams's labors in Jamaica. A visit to that island in the winter of 1843–4, enabled him to ascertain just enough of its zoological and especially its conchological riches, to excite a desire in lovers of science that this field might be more thoroughly explored. A hasty examination of but a small portion of the island on that occasion, enriched our catalogues with about 120 new species, of which about 70 were marine, and 50 were land-shells.

In the winter of 1848–9, Prof. Adams made a second visit to this island, and a brief review of the results is contained in the papers named at the head of this article. We see with surprise how rich a field has been lying neglected almost at our doors. The "Contributions to Conchology" contain descriptions of 137 supposed new species of land and fresh-water shells; and these added to those found in the first visit, make a total of 187 species contributed to science by Prof. Adams. The extent of this "contribution" will be appreciated, when it is observed that the whole number of land and fresh-water species yet known to inhabit the island is only 286.

The operculated species constitute a large share of this increase; of 101 species from Jamaica, 66 were discovered by Prof. Adams. Among them there is a new genus called *Stoastoma*, characterized by a semicircular aperture and projecting labrum, embracing as far as known, about a dozen species, all minute, and forming a connecting link between Cyclostoma and Helicina. Many of the new species of Cyclostoma are remarkable for their beauty, as for instance, C. Augustæ, C. proximum, C. 5-fasciatum, and C. ignilabre; and others for the novelty of their forms, such as C. monstrosum and C. tectilabre, in which last the operculum is much larger than the aperture, and is of course entirely external. The genus Trochatella furnishes some beautiful species, of which T. Tankervillei, *Sow.*, and T. Josephinæ, *Adams*, are worthy of note—the latter forming a connecting link between the typical species of the genus and that most elegant of land-shells, the T. pagoda Velasquez, from the Isle of Pines.

Of the 157 species of Jamaica Helicidæ, Prof. A. has contributed more than 100, many of them of unusual beauty, and of which we instance Cylindrella Agnesiana, Achatina elegans and the group it represents, Helix peracutissima, H. fluctuata, H. virginea, &c.

Professor Adams has also contributed much, bearing upon the important subject of geographical distribution. The most striking result presented, is that while the marine species of the West Indies are widely distributed, some few extending to Brazil, to our Southern States, and even to West Africa and the Mediterranean, and not more than ten or fifteen per cent. being peculiar to Jamaica,—the case is quite the reverse with the terrestrial shells, not more than six to nine per cent. of the Jamaica species being common probably to this and any other island. Dr. Gould has noticed similar facts in examining the terrestrial shells from the several islands and groups in the Pacific, and from the little we know of the fauna of the other West India islands, there is reason to believe that the law will hold good in regard to most of them. Of the few species which are common to the islands in general, many, there is reason to believe, have been distributed by human agency. Of the 230 species of Helicidæ on the contiguous islands of Jamaica and Cuba, only *nine* are said to be common to both, and a closer examination of the specific character of these, will probably show some of them to be really distinct. Nor can we suppose that future explorations will materially alter the per-centage of community of species, for since most of them are restricted to limited localities—such researches will increase the number of new and peculiar species, in at least as great a proportion as of those common to other islands. These facts show that the field open to the conchologist in the tropical archipelagos is far wider than was ever supposed. For if an examination of one tenth of the surface of Jamaica has led to such results, how will our future catalogues be swelled with the lists of species still undiscovered on that island and the other great islands of Cuba, Hayti, Porto Rico, besides the many of smaller extent. And if this law holds true of different islands of the same group, how much more in regard to groups which are widely separated? It renders almost certain, what at one time would have been thought impossible—that the existing species of terrestrial shells may far outnumber the marine species.

Some remarks upon the different proportion in which certain genera of land shells are distributed in the eastern and western hemispheres, may not be out of place here. Of the genus *Clausilia*, so abundant in the old world, and especially in the southeastern parts of Europe, and now embracing about 200 species, but one has been found upon this continent. One species only is known in the West Indies, and this is an aberrant form, quite different in aspect from those of Europe. But the place of this genus is well supplied in tropical America by *Cylindrella*, of which about 70 species are already known, more than 30 of them existing in Jamaica. On the other hand, the Philippine Islands furnish the only species of *Cylindrella* which is known to exist in the eastern hemisphere. The genera *Proserpina*, *Tomigerus*, *Gesmelania* and *Stoastoma*, are, as far as known, confined to the western hemisphere, while with only one or two exceptions, *Vitrina* has been found only on the eastern. *Achatinella* and *Pupina* are restricted to the islands of the Pacific, and *Tornatellina* as yet contains but one West India species.

The following table, although based on data necessarily imperfect in the present state of our knowledge, may have some interest in showing the proportion which the known terrestrial species of Jamaica, bear to those of the West Indies,—and also the proportion which the latter bear to the known terrestrial species of the globe.

	Total No. of known species.	No. of known West India species.	No of known Jamaica species.	Proportion of W. I. species to the whole.	Proportion of Jamaica spec's to the whole.
Fam. CYCLOSTOMIDÆ.					
Truncatella,	15	4	8	27 per cent.	20 per cent.
Pupina,	10	0	0	0 "	0 "
Cyclostoma,	800	82	63	27 "	21 "
Stoastoma,	11	11	11	100 "	100 "
Helicina,	160	54	24	34 "	15 "
	496	151	101	37·6	20
Fam. HELICIDÆ.					
Daudebardia,	3	0	0	0 "	0 "
Vitrina,	60	0	0	0 "	0 "
Succinea,	75	14	4	19 "	5 "
Helix,	1,250	151	61	12 "	5 "
Anostoma,	3	0	0	0 "	0 "
Tomigerus,	2	0	0	0 "	0 "
Streptaxis,	26	0	0	0 "	0 "
Pruserpina,	6	4	2	67 "	33 "
Bulimus,	700	39	16	5½ "	2 "
Achatinella,	30	0	0	0 "	0 "
Achatina,	192	51	28	26 "	15 "
Gibbus,	2	0	0	0 "	0 "
Gesmelania,	4	4	4	100 "	100 "
Cylindrella,	69	57	35	83 "	51 "
Balea,	9	0	0	0 "	0 "
Tornatellina,	11	1	0	9 "	0 "
Clausilia,	225	1	0	½ "	0 "
Pupa,	175	23	9	13 "	5 "
	2,842	345	159	12 "	5½ "

The family of Auriculidæ has not been worked out with sufficient accuracy to institute a similar comparison, but the whole number of known species contained in it does not probably exceed 100.

The following table, which is made up from such data as are furnished in Pfeiffer's Monographia Heliceorum:

Cuba,	92 species.	Barbadoes,	7 species.
Jamaica,	145 "	Granada,	
Hayti,	10 "	Trinidad,	
Porto Rico,	16 "	Bahamas,	3 "
St. Thomas,	13 "	Bermuda,	4 "
Tortola,		General,	5 "
St. Croix,		Uncertain,	14 "
St. Vincents,	8 "		
Guadaloupe,	27 "		344 "
Martinique,			

The table is of use only to show how little we yet know of the other West India islands. In this estimate, which is confined to the Helicidæ, each species is referred to the island or group, supposed to be its proper habitat.

We are happy to say that Prof. Adams is engaged upon an extended monograph of the shells of Jamaica, in which his labors will be presented to the world in a more complete form, and it will no doubt be eagerly awaited by the lovers of natural science. J. H. R.

5. *Eryx maculatus, a new species from Madras;* by EDWARD HALLOWELL, M.D., (Proc. Acad. Nat. Sci., Philad., July, 1849, p. 184.)—Head of moderate size, depressed, covered with scales, larger in front; rostral plate large, triangular; a single nasal plate on each side; nostril small; thirteen labial plates margin the upper jaw; pupil vertical, eye surrounded by a circular series of plates; iris brownish red; neck of same size as head posteriorly; body thicker in the middle, becoming somewhat slender towards the tail; scales small, carinated; a row of single plates under the tail, followed by others which are bifid; tail short, truncate, (mutilated?)

Color.—Light brown above, with numerous spots of the same tint but darker; abdomen light slate color.

Observations.—This beautiful reptile was pointed out to me so long ago as 1840, by the late Dr. Harlan. It was brought from Madras, in the neighborhood of which it was found upon a sandy soil. It appeared to be perfectly harmless. The drawing was taken during life by Mr. Richard, and is remarkable for its accuracy. The above short description is made up from it, the notes which were written during its life having been mislaid. It is so good however, that a description of any kind is almost unnecessary. The entire length was about one foot and a half. I have long hesitated to publish a description of this animal, coming as it does from a part of the British possessions so well known as Madras, but having recently observed in the Annals and Magazine of Natural History, several species of reptiles described by Mr. Gray, as new from the same locality, not being found in the British Museum, and differing so entirely as it does from any figure of Eryx hitherto published, I have ventured to present it to the Academy with the name I have given it.

6. *Descriptions of four new species of North American Salamanders, and one new species of Scink;* by Prof. SPENCER F. BAIRD, (Jour. Acad. Nat. Sci., Philad., [2], i, 292.)—The following descriptions conclude a memoir exhibiting great research, which presents a revision (without

descriptions) of all the North American Tailed-Batrachia. The author gives a thorough review of the synonymy, with references to all original authorities, and a notice of localities.

AMBYSTOMA MACRODACTYLA, *Baird*. Scull longer than broad. Toes long, unwebbed. A broad dorsal reddish brown stripe. Beneath dark brown, unspotted.

Specimens in the Academy of Natural Sciences of Philadelphia. Brought from Astoria, Oregon, by J. K. Townsend, M.D.

Body rather more slender than in the other species of *Ambystoma;* the proportions nearly those of *Desmognathus fuscus*, (Raf.) The colors somewhat like those of a badly preserved *Plethodon erythronotus*, (Green.) Ground color dark brown. A broad dorsal stripe, originally, it is probable, of a chestnut brown color, now very obscure. Sides sprinkled with grayish. The brown of the sides becomes more concentrated towards the vertebral line. Tail sub-round, not compressed. Largest specimen about 2¾ inches. From the snout to the insertion of the hind legs 1½ inches.

AMBYSTOMA MAVORTIA, *Baird*. Scull broader than long. Toes short. and broad. Tail much compressed. Color dark brown, with several large yellowish blotches beneath, and transverse bands of the same on sides of body and tail.

One specimen procured in New Mexico by Dr. Wislizenus while attached to Col. Doniphan's expedition.

Body thick and clumsy, more so than in *Ambystoma punctata.* Feet short; toes broad. Tail slightly ensiform; longer than the head and body.

General color (as preserved in spirits) a dull black or dark brown, with two or three yellowish blotches occupying the greater part of the belly. About nine broad transverse bands of yellowish on the sides of the body, confluent to a certain extent with that on the belly. Similar markings on the tail, forming nearly complete ellipses, and about twelve in number. The back is not crossed by the yellowish, but is rather darker than the ground color. The interspaces of the transverse yellowish markings are confluent with the dark brown on the back. Extremities blotched like the body. Total length eight inches.

This species comes nearest to *Triton ensatus*, Esch.; it differs from it in color, and in the arrangement of the palatine teeth.

AMBYSTOMA EPISCOPUS, *Baird*. Head wedge-shaped. Scull longer than broad. Tail much compressed, shorter than the body. Body yellowish with dark mottlings and darker spots.

One specimen sent by Clinton Lloyd, Esq., from Kemper County, Mississippi.

Proportions of the body nearly those of *Ambystoma opaca*, Grav. The specimen much corrugated, and its colors obscured by alcohol. The general color appears to have been a shade of yellowish over the whole body, obscured on the back by very minute dusky mottlings: this mottling less evident on the feet and tail; abdomen and tail beneath almost entirely free from it. Head, back, and sides of the tail with numerous spots of a darker mottling than that just described. These are sub-circularly distributed rather uniformly on the head and body; they are larger, and more irregular on the sides of the tail;

their average size is that of the iris. On the sides, between the fore and hind legs, the dark mottling is concentrated into an obscure broad dark band. Length about five inches.

PSEUDOTRITON MONTANUS, *Baird.* Similar to *P. ruber*, (Daud.) Tail as long as the body. Iris dark, without the longitudinal bar.

Two specimens obtained in the South Mountain, near Carlisle, Pennsylvania.

Ground color of all the upper parts reddish brown, with sparse circular spots of well defined black or dark brown. Beneath deep salmon color: spots few on the sides and the outside of the limbs. Iris dark chestnut brown almost black, with faint mottlings of bronze on the inner border, and without the dark bar of *P. ruber.* In this latter species the iris is brassy yellow with a dark longitudinal bar. Proportions of body most like those of *P. salmonea*, (Storer.) The insertion of the hind legs is just half way between the snout and tip of tail. In *P. ruber* it is considerably nearer the tail, which thus becomes shorter than the head and body. The crown of the head is more elevated, and the occiput more convex in *P. montanus* than in *P. ruber*, the scull also is more elongated. The spots on *P. ruber* are more numerous, and generally not so well defined. When also the ground color in *P. ruber* is darker than the usual rich salmon color, the spots are very much crowded, indistinct, and confluent with the ground tint. Costal furrows in *P. monatus* 17; but 16 in *P. ruber.*

Of the two specimens obtained, one was six inches long, the other three. The latter was even more characteristically marked than the former. Both were described when living.

PLESTIODON ANTHRACINUS, *Baird.* Size between *Lygosoma lateralis* and *Plestiodon fasciatus*, without any indication of a vertebral line. Four narrow longitudinal yellow lines, and on each side a broad stripe of anthracite black.

Upper parts dark bronze; each scale has a faint border of this color, with a central cloud of the same. Small blotches on the plates of the head. The lateral band of black begins at the nostril in a sharp point, passes back including the eyelids and widening to the ear; after this it continues parallel to beyond the vent, when it tapers to the end of the tail. The tint of the black is that of highly polished anthracite coal. On each side of this lateral anthracite band is a narrow stripe of pale yellow, the upper passing through the middle of one row of scales, the lower including the contiguous edges of the rows. The remainder of the row of scales above the upper yellow stripe is also anthracite, with which color the sides immediately below the lower stripe are also tinged. Beneath yellowish white. Under the microscope each lower scale exhibits a finely dotted reticulation. Tail dark blue above, beneath lighter. Outside of legs and feet black like the sides, inside lighter. Iris black. In a single very old specimen the whole head to behind fore legs was tinged with the red color found in almost all of the *Plestiodontes.* Measurements of a specimen of medium size: total length 5¼ inches; tail from vent 3¼; head to ear ⅜; breadth of head ¼; greatest breadth of dorsal band $\frac{3}{16}$; of lateral band ⅛.

Found quite abundantly about old logs, in the North Mountain near Carlisle, Pennsylvania. More common than either *Plestiodon fasciatus*, or *P. quinquelineatus.*

7. *On Infusorial Deposits on the River Chutes in Oregon;* by M. Ehrenberg, (Monatsb. Acad. Berlin, Feb., 1849, p. 76.)—Ehrenberg first draws attention to the results of his former researches, that the Rocky Mountains are a more powerful barrier between the two sides of America, than the Pacific Ocean between America and China; the infusorial forms of Oregon and California being wholly different from those of the east side of the mountains, while they are partly identical with Siberian species. This fact is confirmed by his examinations of earth from the gold region of California, and from the Chutes river of Oregon, obtained by Fremont. The latter deposit is situated at an elevation of seven to eight hundred feet, and constitutes a bed five hundred feet thick of porcelain clay. It is overlaid by a layer of basalt one hundred feet thick.

Prof. Bailey who examined this material for Fremont, reported that it consisted of fresh water infusoria, and many species were distinguished.* Ehrenberg on farther investigation has made out seventy-two species of polygastrica with siliceous shells, sixteen species of phytolithuriens, and three of crystalline forms. The more prevalent species are *Discoplea oregonica*, *Gallionella granulata*, *G. crenata*, *Eunotia Westermanni*, *Cocconema asperum*, etc. The Discoplea and Raphoneis oregonica are the only two species characteristic of the locality. The beds are more recent than those of the Klackamus river, a few miles from the Falls of the Willammet.

8. *On the Fossil American Tapir;* by Joseph Leidy, M. D., (Proc. Acad. Nat. Sci., Philad., June, 1849, p. 180.)—Dr. Leidy in his memoir describes portions of the fossil Tapirus americanus, and sustains the view that it is identical with the recent T. americanus.

IV. Astronomy.

1. *On Nebulæ observed with Rosse's Telescope,* (Proc. Brit. Assoc., 1849, Athen., No. 1143.)—At the meeting of the British Association at York, in 1844, it was announced that a reflecting telescope of six feet aperture, which had been about two years in progress, was nearly completed, and some slight account was at the same time given of the means which had been taken to render the instrument convenient and effective. A short notice of the principal results which have since been obtained may perhaps not be uninteresting to the present meeting. In the beginning of February, 1845, the instrument was so far finished as to be useable, and in the first instance it was directed to some of the brighter nebulæ in Herschel's Catalogue. Many of them were immediately resolved, and very frequently the aspect and form of well-known nebulæ were completely changed, fainter details not previously seen being brought out by the great light and magnifying power of the telescope. Before the end of April the wonderful spiral arrangement in 51 Messier was discovered. The speculum, though there was a slight defect of figure, was in fine working order, and defined with great sharpness when the air was steady. At the approach of the short nights when the season for observing the nebulæ was nearly over, the instrument

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* Fremont's second Expedition, p. 302.

was dismounted, as it was desirable to take the earliest opportunity of completing certain portions of the mechanism which had been put together in a temporary way in a rough state, and it was not till the close of the year that it was again in working order. During the year 1846, the examination of the nebulæ in Herschel's Catalogue was continued, many sketches were made, and another spiral nebula was discovered, 99 Messier. The moon was observed occasionally, and the superiority of the instrument with six feet aperture over that of three under equal magnifying powers in bringing out minute details was very remarkable, so great is the effect of light even when we have to deal with an object so bright as the moon with an aperture of three feet. As yet, however, but little time has been devoted to an examination of the moon: the moonlight nights have usually been taken advantage of for experiments on the polishing and figuring of the mirrors, and the information which has been obtained relates principally to matters of detail from which it would be premature to attempt to deduce general conclusions, suitable to the present notice. The succeeding year, 1847, there was but little done. Unprovided at that time with an assistant capable of making trustworthy use of the pencil and micrometer, and being almost wholly occupied with the duties incidental to a year of famine, it was impossible to do more than re-examine a few of the objects of the previous year. From the beginning, however, of the year 1848 till the present time, the instrument has been constantly employed whenever the season and weather permitted it, and the following are some of the results:—

H 604 was found in some degree to resemble the great spiral nebula 51 Messier, but it is a much fainter object, and appears to be made up of elliptic streaks disposed rather irregularly with a tendency to spirality, but without that distinct symmetrical spiral arragement which is so marked a feature of 51 Messier. If H 51 Messier were seen somewhat obliquely and were considerably fainter it would probably very closely resemble it. H 854 has an arrangement of very elliptic annuli and is apparently a system of the same class seen very obliquely. H 838, M 97 is a very extraordinary object, with a dark hollow centre somewhat in the shape of a figure 8 easily seen; and with a disc irregularly shaded, but showing in the shading a decided tendency to spirality when seen under favorable circumstances; two stars are placed in a remarkable manner in the central opening. We may conceive it to be a spiral system greatly compressed; the edges are filamentous. H 2205 has a faint but large spiral appendage, to which the ray as figured by Herschel is in some measure a tangent. Several other nebulæ are recorded in our note-books as belonging to the class of spirals. The well-known planetary nebula in Aquarius, H 2098, which, in former years, had been often examined with a telescope of three feet aperture, and with no other result than that it exhibited a filamentous edge, when seen with the great instrument, was found to have two ansæ like Saturn. Many have since seen it, and the resemblance to Saturn out of focus has usually suggested itself. It is probably a globular system surrounded by a ring seen edgeways; while H 450—which turns out to have a bright centre surrounded by a comparatively dark ring, and that again by a bright ring—though a much fainter object, is not improbably a system of the same characters seen directly. H 84 and

86 is a remarkable group of nebulæ. It consists of eight, two of them pretty bright. Such groups are not uncommon, but in this instance there are, I believe, more nebulæ in a given space than in any other group we have noticed. It was observed by Mr. Stoney. The nebulæ were not connected by any perceptible nebulosity, but there are cases where a nebulous connection was distinctly traced; several minute nebulæ, or nebulous knots hanging together as it were by a very faint but unmistakable nebulosity. The nebulæ of Andromeda and Orion have of course been observed. As to Andromeda, there seems to be little doubt that the companion is resolvable, and the nucleus of the great nebula has that granular appearance,which indicates resolvability. It has however, not been seen as yet under very favorable circumstances, and we have not commenced a sketch of it. The nucleus was examined on three occasions, and the abrupt edge of the preceding streak in Mr. Bond's drawing was traced to its visible limits; but unfortunately he did not receive the drawing till the nebula was out of reach, otherwise of course more attention would have been directed to it. Subsequent to the receipt of the drawing, the nebula was seen by Mr. Stoney in my absence with the instrument of three feet aperture, but at a distance from the meridian. The appearance was very much as in Mr. Bond's drawing, except that the contrast between the preceding portion as bounded by the preceding edge of the preceding streak, and the following portion of the nebula, was much greater. The question, however, of most interest is, what do these streaks indicate? With the great instrument, dark streaks have been observed in many of the nebulæ—sometimes almost straight as in Andromeda; for instance, H 887, H 1909, H 1041, H 1149, are cases in point, the streaks being nearly straight. H 1357, to which Mr. Bond refers, is if possible a still stronger case than it appears to be by Herschel's drawing, as I find a sketch in our journal showing that the appendage is part of the nebula, the nebulosity extending and encasing both extremities of the opening just as in Andromeda. We have also found a variety of examples of curved streaks; for instance H 264, H 491, H 406, H 731, H 854, H 875, H 1225, and others. Also H 1486, H 464, H 2241, besides the well-known annular nebula and the little annular nebula, figure 48, sketched by Herschel, are some of the examples of nebulæ with comparatively dark centres; the darkness being apparently of the same quality as the dark streaks but of a different shape.

With these facts therefore I think it not improbable that the dark lines noticed by Mr. Bond in the nebula of Andromeda, and which with sufficient power are perceptible in so many other nebulæ, sometimes nearly straight, sometimes variously curved, and also the dark spaces, are all indications of systematic arrangement. When we see a dark space in the centre of a planetary nebula, it is impossible to resist the impression that we are looking at an annular system bound together by some mysterious dynamical law. If we see a bright centre as in H 450 surrounded by a dark annulus, and that again by a bright annulus, we have a system of another kind, and in the spirals of which 51 Messier is the most remarkable example we have yet found, we have a regularity of arrangement equally accordant with our preconceived notions of the order which should subsist in a regular independent system. The very elongated elliptic annular nebulæ where the minor axis is sometimes almost evanescent, shew us pretty clearly the nature of the slight, long, dark, and nearly straight streak in some cases found parallel to the axis of a long ray. A little consideration of the appearances which annular and spiral systems must present when viewed in different positions, in some instances affords a pretty satisfactory explanation of the confused streakiness we have observed in several of the nebulæ. This, however unsatisfactory it may appear, is the best explanation our working journal books at present afford of the streaks observed by Mr. Bond in the nebula of Andromeda. Mr. Bond's paper has excited so much interest, and I have been so often questioned relative to it, that I have prematurely, in anticipation of more numerous sketches and measurements, which will probably throw additional light on the subject, ventured to lay before the Association the very little which is at present known to us. It was in the spring of 1846 that we first perceived the brighter portions of the nebula of Orion in the neighborhood of the Trapezium breaking up into minute stars. Whenever the sixth star was nicely separated, this appearance was clearly perceptible. We had repeatedly examined Orion with the telescope of three feet aperture without a suspicion of its being resolvable; however, its resolvable character once known we were enabled with it on very fine nights to see some of the stars. With the six feet telescope the space within the Trapezium is still dark, just as Herschel describes it, and I feel convinced there is no optical illusion. Last season my attention was directed by Mr. Stoney to Orionis, which is on the edge of a dark spot; the dark spot includes the companion, and is about 12″ diameter; we have not yet had an opportunity of examining it with the great instrument. A few copies from our collection of sketches accompany this notice; they have been made within the last day or two by a drawing master in the neighborhood. He has transposed white for black, and enlarged the scale to make them more suitable for exhibition in the Section. In sketching we employ solely the black lead pencil, black representing light, and the eye by habit makes transposition without effort. The copies are not quite accurate, but they are sufficiently exact for the purpose.

2. *A Model of the Moon's surface.*—Mr. Blunt exhibited a model of part of the moon's surface, at the recent session of the British Association. It represented the moon as it appeared through a Newtonian telescope of 7 ft. focus and 9 in. aperture, under a magnifying power of about 250.

V. MISCELLANEOUS INTELLIGENCE.

1. *Meteorite in North Carolina.*—On the authority of a communication from J. H. Gibbon, Esq., of the Branch Mint of the United States at Charlotte, North Carolina, we give a condensed view of facts regarding a fall of meteoric masses in that state, not having room for the less important details.

On Wednesday, the 31st of October, 1849, at 3 o'clock, P.M., several persons in the town of Charlotte were astonished, and not a few were exceedingly terrified, by a sudden explosion, followed at short intervals by two other reports, and by a rumbling in the air to the east and south.

The sounds were distinct, and continued more than half a minute; they were imputed by some to thunder—but there were no clouds, the evening was calm and mild like the Indian summer, and only a mist was seen in the eastern horizon; nor were the impression of others better founded that the explosions were due to the blasting of rocks on a railroad; but sheriff Alexander having once before witnessed the explosion of a meteor, justly traced the detonation to that cause.

The negroes, who are very acute observers of sounds in the open air, denied the thunder, and an old fisherman said that the reports were like those of three pieces of heavy artillery followed by the base drum. Horses both in harness and under the saddle started with alarm.

Enquiry began to be made for fallen stones, and on Monday a servant of the mint brought in a report from the county of Cabaras, twenty-five miles distant, that there were notices stuck up on the trees, inviting people to come and see "a wonderful rock that had fallen from the skies on the plantation of Mr. Hiram Post."

Mr. Gibbon of the mint, with Dr. Andrews, travelled twenty-one miles, and partly at night by torch-light, to see "the large mass of metallic rock." They found placed in a conspicuous position upon a barrel elevated upon a post,* "a bluish gritty rock," of irregular form, eight inches long, six broad and four thick, bearing marks in spots, of recent fracture, but otherwise black as if it had been exposed to heat and smoke, the black color being relieved where the crust had been broken, and a little of the clayey soil in which it was buried in its descent still adhered to it. It had the curved indentations usual in meteorites, as if it had been soft and had yielded to impressions, and lustrous metallic points appeared through the ground color, which had generally a bluish slaty appearance, but no such rock was known in the neighborhood. Mr. Post took the travelers by torch-light to see the place where the mass fell. He was at the time in company with a young man on horseback; they heard overhead a whizzing sound—the whole atmosphere appeared to be in commotion—they compared the sound to that of chain shot, or of platoon firing. Nothing was visible; but their attention being directed by the sound towards a large pine tree east of them, they heard the stone strike "with a dull, heavy jar of the ground," while the dog, in terror, crouched at his master's feet.

Mr. Post, (in his peculiar language,) had *sighted* the sound, and his negro man ploughing in a field had done the same from a different direction, and by ranging with the aid of these intersecting lines, they the next morning found the stone, which had splintered a pine log lying on the ground; by sounding with a sharp stick in the hole made by the stone in its fall, they soon found it, and extricated it from its hiding place, which was ten inches below the surface; the dried leaves which had been "driven about by the percussion, aided in discovering the spot, about three hundred yards from the place where Mr. Post had stood at the moment of the fall, which was in the woods, but there were no marks on the trees—although the impression was that numerous small bodies had fallen, "making a noise like hot rocks thrown into water."

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* With laudable liberality and caution joined, the worthy proprietor of the boon which had fallen on his land—had annexed a written notice—"Gentlemen, sirs—please not to break this rock, which fell from the skies and weighs 19½ pounds.
HIRAM POST."

Mr. Gibbon and his companion viewed the place both by torch and daylight, and were convinced of the accuracy of the statement.

The people of the vicinity imagined that a rock had been thrown up from a volcano or from blasting, or had come from the moon, and were not easily persuaded that it could be formed in the atmosphere.

As is usual in cases of extraordinary celestial phenomena, some were terrified by the supposed approach of the day of judgment, or of war, or some other dire calamity, and a militia colonel, in a spirit quite professional, said that "there must be war in heaven, for they were throwing rocks."

At the request of Dr. Andrews, the stone was diverted from another destination, in favor of Prof. Charles U. Shepard, of the Medical College of South Carolina at Charleston—from whom we learn that at a recent date the specimen had not yet reached him.

In due time we shall have the result of his scientific examination; but from the circumstances we have no hesitation in admitting this case as genuine: the facts are perfectly familiar to hundreds on record, and in many particulars are in accordance with the remarkable event of this nature which happened in Weston, Connecticut, in December, 1807, and with which the senior editor of this Journal, with his college colleague, Prof. Kingsley, was at the time familiar. There is no room to discuss theories, but we feel fully assured that aerolites are not formed in our atmosphere, are not projected from terrestrial or lunar volcanoes, but have a foreign origin, giving us the only reports of the physical constitution of other worlds which have ever reached our earth.

By an additional communication from J. H. Gibbon, Esq., dated November 29, 1849, it is rendered probable, that "luminous materials were seen advancing from several points in the atmosphere towards a common centre, where a solid mass of heated metal (materials) exploded and was violently projected in different directions to the earth."

It is stated also that there was a distinct appearance of a single fiery elongated body, like iron advanced to a white heat, sparkling in its passage from west to east, rising like a rocket but not vertically, and passing through the air with a long white streak or tail following a denser body in the form of a ball of fire.*

Still it is to be observed that neither the fire ball nor any light was seen by many who heard the successive reports and the fall of the stones, and the rumbling "like loaded wagons jolting down a rocky hill,"† but this is no way extraordinary, as it was day time, with a clear sky, and those only would see the fire ball who were looking in the proper direction at the time "when it was in its most ardent state." At the explosion, the meteor was about 45° high.

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* "The true flaming sword of antiquity."

† This was the very comparison used at Weston, in December, 1807, by the people there, in describing a portion of the reports heard on that occasion.

The estimation of time between the disappearance of the light and the arrival of the sound was very different, as made by different persons, at several minutes, even as high as five. The latter supposition would make the meteor almost extra-atmospheric, but doubtless the period of five minutes is much too high, and we infer that the meteor, like that at Weston, was fully within the atmosphere, and probably not over fifteen or twenty miles from the earth when it exploded. It was seen through 250 miles from the line of Virginia, to Sumpter district in South Carolina, and from east to west it was seen through sixty miles.

2. *Further Contributions to Anemometry;* by Prof. Phillips, (Proc. Brit. Assoc., in Athen., No. 1145.)—Referring to his former reports on this subject [see Ath., No. 987, p. 994, and No. 1088, p. 887], the author said that his researches into the force and velocity of wind have been directed to the completion of a method of wind registration which should be independent of mechanical movements, momentum and friction. He wished to register the wind by one of the effects of the displacement of its molecules, not the movement of its mass. For this purpose only one method has occurred to him as sufficiently applicable, viz., the evaporation of a liquid. He had experimented on water, saline solutions and alcoholic mixtures, and he found reason to think that with either of these liquids an instrument really indicating the movement of wind by the registration of the evaporation which the wind causes, is producible. Such an instrument need occupy but a very small space, and will have the desirable quality of being most accurate in those very low velocities of wind which elude entirely Lind's Anemometer and are scarcely sensible by any registering machinery. It will be remembered that for the interpretation of the register of evaporation with a register of wind velocity, it was necessary first to correct for the hygrometric state of the air. This being done, the cooling power of wind was found by experiment to be nearly as the square root of its velocity. In this experimental result, Prof. Phillips was induced to place confidence, because it appeared to represent and flow naturally from what may be thought the true physical action of the moving air. Having lately had occasion to examine extensively and carefully into the amount of air which passes (or is made to pass) through the rarefied passages of collieries, where the currents are sometimes so slow that machine anemometers even of a most delicate description are insensible to the movements of the air—where even the miner's candle affords but a rude guess, and where the situation is such that smoke or the powder-flask cannot be appealed to—he was happy to find that the problem was perfectly and easily solved by noting the cooling power of the current. For this purpose a registering or integrating anemometer is not required. The currents underground are steady, and required only an anemoscope or indicater of the momentary velocity. Evaporation from the wet bulb may therefore be abandoned; the common thermometer with its bulb clear of the frame will answer the purpose of experiment, in every conceivable instance.*

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* It appears from Prof. Forbes's 'Report on Meteorology' to the British Association in 1832, that the idea of employing a thermometer for indicating the velocity of wind was entertained by Prof. Leslie.

3. *Discovery of another huge reptile by Dr. Mantell.*—Dr. MANTELL has added to his interesting discoveries of fossil lizards, an arm bone or humerus fifty-four inches long. "It is closely allied in form and proportion to the humerus of a crocodile." Dr. Mantell has sent to the Royal Society a memoir on the subject of this new species, and it will probably be soon published.

4. *Colossal Birds of New Zealand*, (Lit. Gaz., Nov. 17, 1849.)—The splendid collection of the remains of these gigantic bipeds, formed by Mr. Walter Mantell of Wellington, announced a few weeks since, has arrived in safety, and contains objects as marvellous and interesting as the one previously transmitted by the same enterprising young naturalist, and which is now in the British Museum. The present collection consists of upwards of 450 bones, referable to several genera of birds. One series is in the same condition as those formerly received by Dr. Mantell, and among which were the skulls and mandibles and egg-shells described by Prof. Owen in the Zoological Transactions. These are from the west shore of the north island, and were dug up from a bed of marl and volcanic sand. The other series is from a tertiary deposit, on the coast of the south island, at a place called *Waikonaiti*. These bones belong principally to the colossal Dinornis, the *D. giganteus*, &c. The gems of this collection are *two entire legs and feet* (that is, the *tarso-metatarsal*, *phalangeal*, and *ungueal* bones) of the same individual, which were found erect, about a yard apart, in the very position in which they were when the bird was alive; the twelve bones of each foot, together with the *tarso-metatarsals* are as fresh and perfect as if inhumed but a few years. Indications of winged birds, of genera, and probably species, still indigenous to the islands, are among these treasures; which also include numerous *pleistocene* (or newer tertiary) shells, and specimens of rocks and minerals, collected by Mr. Walter Mantell during his late journey through the south island, as government commissioner for the purchase and allotment of the land recently obtained.

5. *Cabinet of Geology and Mineralogy for sale.*—The cabinet of the late Lardner Vanuxem of Bristol, Pa., is offered for sale. The cabinet consists of a very good collection in mineralogy, European and American; and a geological collection embracing a very complete series of all the American formations, with large numbers of the characteristic fossils of the palæozoic and cretaceous periods; the whole very completely arranged, with labels of localities, sections illustrating relative position, &c. This collection, for teaching the geology and palæontology of the United States, is superior to any other collection which can be procured at the present time. For more particular information, address James Hall, Albany, N. Y.

6. *Correction.*—In the notice of Capt. Cullum's work on Military Bridges, it is stated that the work was published by the "Engineer Department" of government. There are strictly two Engineer Bureaus, and that which receives the general title, is the Bureau of the Engineers of Fortifications. The other, the Bureau of Topographical Engineers, has in charge a series of publications, No. 4 of which is Capt. Cullum's able work.

VI. BIBLIOGRAPHY.

1. *Endlicher, Generum Plantarum Supplementum Quartum: Pars II.* Vienna, 1847.—This second part of the 4th supplement was made to anticipate the first, which, we believe, remained unpublished at the untimely death of the accomplished Endlicher, in March last. Beginning with the Coniferæ, which the author had recently made the subject of a special study, the present fasciculus goes on through the Exogenous Apetalous orders only. Under several of the orders, such as the *Betulaceæ*, *Cupuliferæ*, *Polygoneæ*, *Daphnoideæ*, and *Proteaceæ*, a complete systematic enumeration of species is given. A. GR.

2. *Endlicher, Synopsis Coniferarum.* Saint Gall. 1847. 8vo. pp. 368.—This interesting monograph of a small, but most important family or class of trees, bears the marks of the vast learning and untiring industry of its lamented author. It treats, 1st, the *Cupressineæ*, which are divided into five groups. A genus *Libocedrus*, is established for one New Zealandian and two Chilian trees, formerly referred to Thuja; and *Biota*, a section of Thuja of Donn is raised to the rank of a genus, including the oriental Thuja orientalis, *L.*, and T. pendula, *Lamb.* *Thuja* proper is thus left as a N. American genus, including T. occidentalis, *L.*, T. plicata, *Donn*, and T. gigantea, *Nutt.* Spach's genus *Chamæcyparis* (Chamæpence, *Zucc.*, Retinospora, *Sieb.* and *Zucc.*) is adopted for our Cupressus thyoides, the C. Nutkatensis of Oregon, and the Mexican C. thurifera, with three Japanese species, which form a separate section. In *Taxodium*, T. microphyllum, *Brongn.*, and T. adscendens, *Brongn.*, are kept as specifically distinct from T. distichum. The genus *Glyptostrobus* is established for the Chinese Taxodium Sinense or Thuja pensilis, *Lamb.* The dubious evergreen species of Taxodium, of Western N. America, no longer find a place even among the Cupressineæ, but are removed to the Cunninghamieæ in Abietineæ, where the author has established for them a genus, under the uncouth and unexplained name of *Sequoia*, S. sempervirens, *Endl.*=Taxodium sempervirens, *Lamb. Pin.* t. 64. S. gigantea, *Endl.*=T. sempervirens, *Hook. & Arn.*, *Hook. Ic. Pl. t.* 379. Much still remains to be made known in respect to these two interesting trees. It is to be hoped that Dr. Torrey will illustrate them from materials which have been supplied to him by Col. Fremont. The true Abietineæ are all resolved into the old Linnæan genus *Pinus*, which Endlicher arranges under the sections:—

A. SAPINUS.

(1.) *Tsuga*, which includes the Japanese Pinus Tsuga, the Himalayan P. Brunoniana, our Hemlock Spruce (P. Canadensis), and the Oregon P. Douglasii.

(2.) *Abies*, comprising our two species of Balsam Fir, five Oregon and Californian, two Mexican, five European and Caucasian, two Himalayan, and three Japanese species.

(3.) *Picea*, including our White, Black and Red Spruce (the latter still maintained as a species), two from our North West Coast, the Norway Spruce of Europe, one Oriental, two Siberian, one Himalayan, and two Japanese species.

(4.) *Larix*, comprising one European, two Siberian, one Japanese, and two North American Larches, one of the latter very doubtful.

(5.) *Cedrus*, the Cedar of Lebanon, and the Deodar of Nepal and Thibet.

B. PINUS.

(6.) *Cembra*, embracing the P. Cembra of Europe and Siberia, P. Peuce of Rumelia, with P. sparsiflora and P. Koraiensis of Japan, the Kurile Islands, and Kamtschatka.

(7.) *Strobus*, for our White Pine, the allied Lambert Pine and P. monticola, of Oregon and the Rocky Mountains, a Mexican species, and the P. excelsa of Himalaya.

(8.) *Pseudo-Strobus*, for fifteen Mexican or Central American species, of which P. Montezumæ is an example.

(9.) *Tæda*, comprising our Long-leafed, Loblolly, and Pitch Pines, eight Oregon and Californian, two Mexican, two Chinese, two Himalayan, one Philippine, and one Persian species.

(10.) *Pinaster*, comprising the P. Pinaster and eight other European and North Asiatic species, two Chino-Japanese, and one Sumatran species, with one from N. W. America, and six natives of Eastern North America.

(11.) *Pinea*, comprising the Stone Pine of the Mediterranean region, the Mexican P. cembroides, and the Californian P. Fremontiana, *Endl.*, which is Dr. Torrey's P. monophyllus, Endlicher having unjustifiably changed the specific name on the assumption that each leaf consists of a pair united.

The *Podocarpeæ*, &c., having no representations in our part of the world, need not be here enumerated.

Of the *Taxineæ*, we have representations of two out of the five genera, namely, *Torreya* (of which the writer in 1839 had occasion to point out the original specimens of Taxus nuciferæ, *Kæmpfer*, as belonging to a second species of the genus) and *Taxus*. One Yew belongs to Europe and Caucasus, one to the Himalayas, one to Japan, one to Mexico, and one to North America.

Of the Gnetaceæ, one genus, *Ephedra*, has a representative in Western N. America.

Our geologists will be pleased to know that the latter part of this volume is occupied by a complete synopsis of fossil Coniferæ.

A. GR.

3. *Contributions to the History of British Fossil Mammals* (*first series*); by RICHARD OWEN, F.R.S., &c. London, 1848.—This memoir is one of the many evidences which have been presented within a short period to the scientific world, of the great activity with which the labors of the most eminent of English naturalists are pursued. It comprises a description of the remains of several genera of extinct animals, under the following heads. I. Description of the teeth of a Palæotherium. II, III, IV. On the teeth and cranium of the Paloplotherium. V. On the dentition of Dichodon cuspidatus. VI. On Megaceros Hibernicus and Castor Europæus. VII. On the genus Hyopotamus, and the species H. vectianus and H. bovinus, with remarks on the classification of the Ungulata.

The systematic zoologist will be most interested in the last of these, which presents an important modification of the classification of Pachyderms and Ruminants, by which the natural affinities of the members of these groups are more perfectly preserved than by the classification adopted by Cuvier in the Animal Kingdom, or by that of any succeeding naturalist. The basis of this change, however, is derived from Cuvier himself. The group of Ruminants has been regarded as quite distinct, and characterized by the absence of incisors in the upper jaw, by the absence of canines, by their complex stomachs, and by the single metatarsal and metacarpal bones. These are characteristic marks of a large portion of the group; but there are a few genera which approximate more or less to that portion of the Pachyderms which, like themselves, have their toes in *even numbers.* The camel has incisive teeth in the upper jaw, and like the musks and muntjacs, has canines. In the Moschus aquaticus and the Anoplotherium, the metatarsus is double, and in all the musks it presents indications in the adult of former separation, and subsequent fusion. If to this statement we add the facts derived from embryology, showing that, in all Ruminants so far as examined, the metatarsal bones are at some period distinct, also the discovery of Mr. Goodsir, that in one species, incisors exist in a rudimentary condition, and of Prof. Owen, that it has an anterior premolar which does not appear in the adult, we shall have abundant evidence that "no very well defined line of separation exists between the Ruminants and Pachyderms. In all the members of the last group whose toes are in even numbers the stomach is more or less complex, while in the Musks the third stomach, the *psalterium*, or maniplies is deficient, and this is the last portion of the stomach developed in the typical ruminants. In view of these and other considerations, Prof. Owen adopts the Linnæan ordinal term UNGULATA, which includes the *Ruminants* and *Pachyderms*. These he arranges in two principal groups, adopting a method which Cuvier had foreshadowed, based upon the odd and even number of toes of the hind foot. This will place all the animals with complex stomachs in one (the even-toed) group, and those with simple stomachs in another (the odd-toed) group.

ORDER UNGULATA.

	ARTIO-DACTYLA. (Number of toes even. Complex stomachs.)	PERISSO-DACTYLA. (Number of toes odd. Simple stomachs.)
Ruminating.	Anoplotherium, Moschus, Antilope, Bos, Ovis, Cervus, Camelopardalis, &c.	Palæotherium. Tapirus. Equus. Rhinoceros, &c.
		PROBOSCIDIA.
Non-ruminating.	Hippopotamus, Dicotyles, Sus, &c.	Mastodon. Elephas.

We cannot close this notice without quoting the following paragraph, the justice of which all who have noticed the course of Cuvier's successor in the chair of comparative anatomy, will unhesitatingly acknowledge. In speaking of one of the illustrations of the correlation of parts discovered by Cuvier, but which Blainville did not have the honor to acknowledge, Prof. Owen says: "in a work of high merit but the tone of which, towards the memory and discoveries of Cuvier every lover of science must deplore, we look in vain for any acknowledgment for the source of the beautiful generalization of the relation of the particular forms of the astragalus, to the parity or imparity of the hinder digits, or any ascription of the credit due to a prevision, which it had been the good fortune of the author of the 'Osteographie' to verify." M. de Blainville both in his published works and public lectures, has not only treated the memory of Cuvier with neglect, but seems to have been actuated by a worse spirit than that of indifference.

J. W.

4. *Iconographic Encyclopædia;* by C. Heck, translated and edited by Prof. S. F. Baird, of Dickinson College, Pa. Part 3.—Rudolph Garrigue, New York.—The plan and character of this work were mentioned with some detail in our last. Part third, sustains all that we observed with regard to the elegant character of the engravings and their finished accuracy and fullness of detail. The plates of this part illustrate Geology, Physical Geography and Botany. The principles of geology are well brought out by drawings that speak to the eye. Stratification, horizontal and disturbed, and structure of various kinds, are illustrated on plates 43 and 46; volcanoes are the subject of many excellent sketches on plates 44, 45; and their geographical distribution on these and other plates, a complete mercator's chart of the world being given on a small scale on plate 47; mountains, waterfalls, caverns, and scenery of different latitudes are presented on other plates—not a mere bald outline, but in pleasing landscapes and scenes, executed in the best style of the art. The botanical department is illustrated with like beauty and fullness. On plate 55, we recognize the magnificent sketch of a species of Banyan, from the Narrative of the Exploring Expedition by Captain Wilkes, volume v, p. 26; on plate 56, a Palm grove on the Island of Fakaafo, from the same volume, p. 14, though with some added shrubs and trees that are never found on Coral Islands; on plate 47, a view of the Antarctic continent from amid the icebergs, from the same work, volume ii, p. 325, besides reduced copies of the sketches of some of the craters of the Sandwich Islands, from volume 4, of Captain Wilkes's Narrative.

5. *The Astronomical Journal,* edited by Benjamin Apthorp Gould, Jr.—No. 1, of the Astronomical Journal, announced in our last, was issued on the 2nd of November last. It appears in a large 4to form. This number is occupied with a memoir by Prof. Peirce on the Development of the Perturbative function of Planetary Motion. No. 2, which has just been issued, contains:—Zodiac of Hygea, by Prof. J. S. Hubbard; on the orbit of the Great Comet of 1843, by the same; on the velocity of the Electrical Wave or current through a metallic circuit, by O. M. Mitchell.

6. *Foster's Complete Geological Chart.*—A large geological chart under this title, some six feet or more square, largely lettered and well varnished, has recently been seen by us. It emanates from Albany, N. Y., and appears to have been intended to illustrate geology to the schools of that state. Strange to say, there is not one word of New York geology to be detected in it, and not even a hint with regard to American rocks. With some truth (in lineal descent from a well known French chart), it combines much that was formerly supposed to

be true, with much that is now known to be false, and is a caricature of geological science though pretending to be made up from the best authorities. It abounds in bad orthography, and includes names of French origin that are not found in English or American works. High up in one corner stands the funniest sort of volcano spitting red streaks of fire, down whose sides are pieces of bitumen in squirming shapes, following one another in parallel lines from top to bottom—a locality for bitumen not hitherto known. The whole thing is below criticism, and however altered or improved, its adoption would be a disgrace to a state that stands so high for its geological researches.

7. *American Almanac and Repository of Useful Knowledge, for the year* 1850.—This periodical sustains its high character for fullness of statistical details and thorough science. The number for 1850 contains, besides its usual range of information, an article by Prof. Lovering, on Melloni's researches in Radiant Heat.

G. A. Mantell, Esq., F.R.S., &c.—Observations on the Osteology of the Iguanodon and Hylæosaurus; 36 pp. 4to, with 7 plates, from the Phil. Trans. for 1849.

Proceedings of the American Philosophical Society, No. 43, vol. v, April to September, 1849.—p. 84, Gold in Maryland.—p. 91, Footmarks near Pottsville, Pa.; *I. Lea.*—New analogy in relation to the periods of rotation of the primary planets discovered by *D. Kirkwood.*

Proceedings of the Academy of Natural Sciences of Philadelphia, 1849, vol. iv, *June*, p. 180. Tapirus Americanus fossilis; *J. Leidy.*—*July*, p. 184, Eryx maculatus; *E. Hallowell.*—Chemical analysis of a calculus of a Whale; *W. Keller.*—*August*, p. 194, A new Cecidomyia; *M. H. Morris.*—The Driver Ants of Western Africa; *T. S. Savage.*—p. 200, Identity of Anomma with Dorylus.—p. 203, New Hymenoptera of the genera Ampulex, Sigalphus, Chelonus and Dorylus; *S. S. Haldeman.*—*September*, p. 210, On the Wheat Midge; *J. W. Dawson.*—p. 211, Species of Termitidæ of West Africa; *T. S. Savage.*—Size of the Brain in different races of men; *S. G. Morton.*—*October*, p. 225, Enterobrus and other new genera of Entophyta, with description of species parasitic in Articulata, &c., with new Entozoa; *J. Leidy.*—On the odoriferous glands of the Invertebrata; *J. Leidy.*—*October*, p. 236, New species of birds of the Family of Caprimulgidæ; *J. Cassin.*

Alfred Smee, F.R.S: Elements of Electro-biology, or the voltaic mechanism of man. 134 pp. 8vo. *London*, 1849.

Uebersicht der Arbeiten und Veränderungen der Schlesischen Gesellschaft für vaterlandische Kultur in Jahre, 1847; mit 6 Tafeln, 400 pp. 4to. Abbildungen. *Breslau.* 1848.

Uranus; Synchronisch geordnete Ephemeride aller Himmelserscheinungen des Jahres 1849, erstes und zweites Quartal, zunächst berechnet für den Horizont der Sternwarte zu Breslau; Vierter Jahrgang. 8vo. *Breslau*, 1849.

Annuaire Magnétique et Météorologique du Corps des ingenieurs des Mines, published by order of His Majesty, Emperor Nicholas I, under the auspices of his excellency, M. de Wrontchenko, Ministre des finances et Chef des ingenieur des mines, by A. T. Kupffer. Année, 1845, St. Petersburg, 1848. 1000 pp. 4to, with numerous plates.

Resumés des Observations Météorologiques faites dans l'étendue de L' Empire de Russie; par A. T. Kupffer. 1er Cahier, 4to, St. Petersburg, 1846.

Annales des Sciences Naturelles, MARCH, 1849.—Researches on Annelida (Helminthidæ); *E. Blanchard.*—On Ferns; *A. Wigand.*—On the genera Quiina and Poraqueiba; *L. R. Tulasne.*—Conspectus generis Hapophyllum; *E. Spach.*—APRIL. On Helminthidæ, continued; *E. Blanchard.*—Embryology of Teredo; *A. de Quatrefages.*—Three species of the genus Anthicus; *L. Dufour.*—Note on Buprestis pulchra; *L. Dufour.*—On "Polypiers," Fam. Astræidæ; *M. Edwards* and *J. Haime.*—On the Cephäelis ipecacuanha; *H. A. Weddell.*—On the genus Ulex and a new species; *J. E. Planchon.*—New species of plants from the Berlin Garden; *Kunth.*—Sixth century of vascular plants; *J. Berkely* and *C. Montagne.*—Descriptions of new plants.

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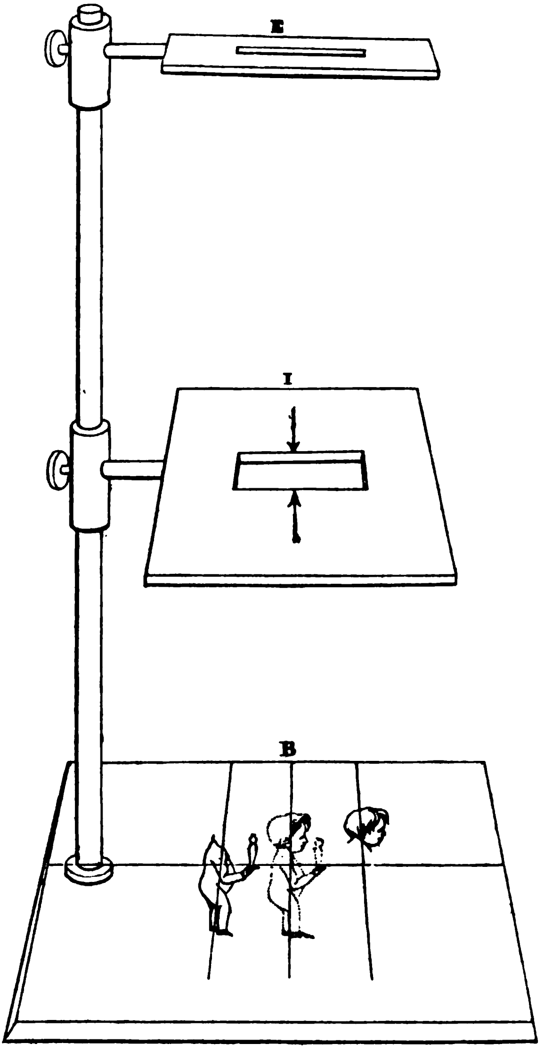
[SECOND SERIES.]

ART. XVII.—*On the Phantascope;* by Prof. J. LOCKE. (In a Letter to the Editors.)

As many persons find it difficult if not impossible to converge the optical axes, (or in common phrase to look "cross-eyed,") for the purpose of making the experiments lately described by me, under the head of "binocular vision," I have invented an instrument which enables all persons to succeed in obtaining the chief results. It is very simple, having neither lenses, prisms nor reflectors, the object being in general the same as holding the finger or other object near the eyes and concentrating the attention upon it for the purpose of optical convergence.

It consists of a flat base-board about nine by eleven inches, with an upright rod at one end bearing two sliding sockets to be clamped at any elevation like those of a retort stand, or adjustable by stiff sliding springs. The upper socket supports horizontally a small vane or card, having a slit or sight hole one fourth of an inch wide and three inches long from right to left. This slit has its middle directly over the center of the base-board, and is intended to have the eyes directly over it, one eye at one end and the other at the other;—two small holes, say one fourth of an inch, occupying the place of the ends of this slit would answer, except for the unequal distances between the eyes of different observers. The lower of the two sockets bears horizontally a movable screen of pasteboard or thin wood, having a slit at least three inches wide from left to right, and about one inch in the other direction, with its center also perpendicular over the center of the base-board. This screen has marked vertically across its middle an index, shown by two arrows in the figures marked I.



E. Eye screen.—I. Index screen.—B. Base-board.

Experiments.—In experimenting with the Phantascope, the operator places whatever is to be tried upon the lower tabular base-board, looks downward through the upper slit and slides the screen up or down until he attains the adjustment required.

Exp. 1.—Let there be two identical letters, say A, placed or drawn on the base-board about two and a half inches apart from left to right, let the movable screen be nearly down, and directing the eye not to the letters, but to the index, draw the sliding screen bearing the index gradually upward; the two letters seen indirectly, will appear as four; or each letter will be double AA AA; continuing to raise the screen and to regard the index, the double images will recede more and more until their position will be thus A A A A; continuing still to raise the screen, the two internal images approach until they are optically superimposed and coalesce into one, thus;

A A A

This middle or superimposed figure, is the phantom or image where there is really no object. Cease to look at the index I, and turn the attention to the base-board itself, and this phantom figure instantly vanishes. If the two letters be placed on the base-board at the same distance as the eyes are apart, say two and a half inches, then this normal position of the screen will be just half way between the eyes and the base-board. If they are placed further apart, the screen must be raised higher; the distance from the eyes to the index screen being in all cases, to the distance from that screen to the base-board, as the distance between the eyes is to the distance between the objects viewed. In the case above, the phantom image is formed exactly as if there were a letter in the area of the index screen of half the size of the primitive letters on the base-board, and optically the letter should appear then, but the knowledge of the observer that there is nothing at that place, will often prevent the deception.

Exp. 2.—Lay upon the base board a card having letters or other figures which are identical in size and form set in regular rows and at equal distances all over, thus:

A A A A A A

A A A A A A

A A A A A A

and proceed to raise the screen as before; you will form phantom images as before between each of these figures, or possibly you will superimpose the first object upon the third, when you will have, not a single phantom but a whole plane of them, each pair presenting a phantom between. This phantom surface will be likely to effect a complete deception, and will rise from the base-board and coincide with the index plane, when it may be contemplated with the same deliberation and ease to the eyes, as if it were a real object. This would be sure to be the case if the index plane were figured over in the same manner, but with figures properly reduced in size.

Exp. 3.—Place two identical pictures of the same flower on the base-board, say they are an inch in diameter, and two and a half inches apart; place also on the edge of the index area, a picture of a small flower pot or vase, with flower stems as an index; then form the phantom image as before, and the flowers will appear in the vase so long as you contemplate the stems at the index screen, but the moment the eyes are directed to the flowers themselves, the phantom vanishes.

Exp. 4.—Let one of the above flowers be red and the other blue; the phantom will be purple. Sometimes however it will appear nearly red and then again blue. This and some other experiments, convince me that the attention of the mind even when we are looking with both eyes, is often directed exclusively to the image in one eye, and perhaps after that tires, the image in the other is contemplated. If this be true, then the two eyes serve in the first place to fix the distance of an object by the amount of convergence, and in the next place to relieve each other by turns.

Exp. 5.—Let there be a horizontal heavy line placed to the left and a vertical one to the right on the base-board, thus: — |, then adjust the screen and superimpose the images to form a phantom. That phantom will be a cross and the whole will appear thus: — + |

Exp. 6.—Do the same with any other parts of a figure of which one shall be the complement of the other; the phantom will be the complete figure. Thus take the picture of a person, cut it out of the paper, and cutting off the head, place the body on one side of the base-board, and the head upon the other, the converged phantom will be the complete figure, the head coming in from one side and the body from the other. It is perhaps unnecessary to say that each part must be placed in its true elevation, though displaced horizontally. It was in repeating this experiment, that I discovered that my eyes did not appear to be mates, for I saw the body clearly but the head obscurely. After a little time however, these conditions interchanged, and I saw the head clearly and the body obscurely. Nor did I seem to have any voluntary control over these conditions, but my eyes continued to relieve guard according to some rule of their own. This is rather an amusing experiment: the figure being beheaded, the phantom ghost appears between the two parts of the body, and from a little unsteadiness of the optical convergence, the ghost's head is inclined to attitudinize, and will sometimes start off a little from the body, and in returning, will go a little too far and will break the neck in the opposite direction. If the head of the experimenter be a little inclined, then the head of the phantom will come on too high or too low.

Exp. 7.—I placed a card having two perpendicular parallel lines about two inches in length and three inches apart. On converging them in an attempt at superposition, I found the converged lines were not parallel but came in contact at the upper end first, and diverged a little downward. Standing with my head erect, I repeated this experiment by converging voluntarily and without the aid of any index, the parallel sides of a window; the same want of parallelism was exhibited, but on throwing my head backward and looking horizontally over my cheeks, the converged perpendiculars coincided throughout. I learned by this that both of my eyes do not rotate in one and the same horizontal plane. I got another person to repeat the same experiment, and he found the error of his eyes to be in the opposite direction, the converged perpendiculars meeting first at the bottoms. This proves a moral adage to be physically true, "we don't all see alike."

This instrument and the researches into binocular vision, serve to extend considerably our knowledge of the anatomy and physiology of vision, nor is the subject by any means exhausted. I have not time to investigate the matter fully, and shall be happy to see fair and honorable competitors enter the field. The verifications and variations of the experiments by your correspondent, Dr. Lathrop, were gratifying to me.

This apparatus will illustrate many important points in optics, and especially the physiological point of "single vision by two eyes." It shows also that we do not see an *object* in itself, but the mind contemplates an image on the retina, and always associates an object of such a figure, attitude, distance, and color as will produce that image by rectilinear pencils of light. If this image on the retina can be produced without the object, as in the Phantascope, then there is a perfect optical illusion, and an object is seen where it is not. Nay, more, the mind does not contemplate a mere luminous image, but that image produces an unknown physiological impression on the brain. It follows that if the nerves can, by disease or by the force of imagination, take on this action, a palpable impression is made without either object or picture. As this would be most likely to occur when actual objects are excluded, as in the night, we have an explanation of the scenery of dreams, and the occasional "apparitions" to waking persons. The murderer, too, has a picture stamped on the sensorium by the sight of his victim, which ever wakes into vibration when actual pictures are excluded by darkness.

Art. XVIII.—*The condition of Trap dikes in New Hampshire an evidence and measure of Erosion;* by Oliver P. Hubbard, M.D., Prof. Chem., Min. and Geol., in Dartmouth College.

In New Hampshire, whose geology is characterized chiefly by primary rocks and metamorphic slates—trap dikes are exceedingly numerous, and they have an evident relation both in position and character to those of the adjoining states. Among them all, none have yet been described, (perhaps not observed,) that are eminent at all above the rocks enclosing them; and there is only one place where the bulk and prominence of the trap is such as to indicate a center of elevation, or greater resistance to erosion, than in the adjacent rock. This is the most northern of the peaks of Ossipee Mountain, east of Lake Winnipisiogee; it is described as "an isolated, bare, precipitous range of bluish greenstone rock," and abundant fragments are found on the adjoining peak, covering the gneiss. From this point as a center, series of dikes seem to radiate in various directions; one group east of Red Hill, ranging north 60° or 70° west, and varying from one to three or four feet in width; another similar one, west of Red Hill, near Squam lake, from one inch to ten feet wide, ranging east and west. "These dikes are distinctly marked over the surface of the granite including them. They have been worn and polished by the action of diluvial currents, so that a level and smooth surface, comprising many thousand square feet, lies entirely bare of soil."*

In volume xxxiv. of this Journal, (p. 105,) I have described a number of trap dikes, presenting the same relations to the enclosing rock, and without doubt there are hundreds of instances of the kind in New Hampshire and Vermont; and they are found at all levels, and continuous for considerable distances. The present condition of these dikes is, obviously, evidence of more or less erosion. I propose to cite in this paper, examples of trap dikes in New Hampshire and vicinity, which shall show how far they are *evidences and measures of erosion*, whether ancient or recent.

The trap in New Hampshire occurs in relation to the surrounding rocks either—1. *Worn off smooth and plane with the adjacent rock*, whether the surface be horizontal or inclined—2. *Below the surface*, when in a state of decomposition and forming, it may be, the channel of a stream—3. *Prominent above*, as at the Peak of Ossipee, and when forming an occasional barrier of a stream, where the surrounding rock has been removed.

There are believed to be very few instances of the third condition. Bear Camp river is crossed by a dike one to two feet wide which forms a barrier, the granite having decayed away. There may possibly be an instance in Red Hill, where the dike is exposed on one (the lower?) side by the removal of the granite.*

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* Geology of New Hampshire, p. 72.

(*a.*) Of the second kind, there is an example in the rear of † the Willey house, referred to by Mr. Lyell in his second tour, and described by me previously in volume xxxiv. of this Journal. The trap is the bed of a small mountain torrent, in some parts decomposing, in others very hard. This dike was traced this season by some members of our party,‡ along a continuous and deep channel far up the mountain, and it is there found to divide into two parts, which again meet a considerable distance above, and thus enclose a large elliptical area. This area is distinctly observable from the house below, as it is fringed with a vivid green of deciduous shrubs, which mark the water courses in the mountains. As there must have been a time when the channel had no existence, and the trap filled it, up to the plane of the mountain, the formation of the water course may fairly be attributed to the decomposition of the dike, and the *depth* of the channel is evidently a measure of the erosion.

(*b.*) The "Flume," in the "Franconia Notch," is a deep chasm ten to sixteen feet wide, "having mural precipices of (very hard) granite on each side," forty to sixty feet high, while a mountain torrent rushes through it at high water. I saw it last June, after a severe drought of some weeks; there was but little water, and no difficulty in ascending it with occasional wading, and climbing over the large angular and rounded rocks in the way. The direction of the channel is north 80° east. At its lower end on the right hand is a trap dike, in several distinct lines each a few inches wide, mounting high in curved plates in the side of the cliff; farther on they decline and coalesce into *one* dike twenty inches wide, which passes under the water.

The dike crosses the fissure obliquely at about N. 75° E., and is seen some rods farther up the stream in a vertical section extending to the top of the opposite bank.

The trap where constantly wet is softened and decomposing, and above on the sides, is compact, very much fissured and stained deep with oxyd of iron. This fissure, like the former, must be admitted to have been filled by the intrusion of trap, and to have become a water channel by the removal of the dike; the channel, therefore, is some measure of the erosion of the trap and its rocky enclosures by existing agency.

(*c.*) The description given in the Geology of New Hampshire of the beautiful Dixville Notch, in the northern part of the state, suggests similar conclusions.

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* Am. Jour. Sci., vol. xxxiv, p. 118. † Ibid, p. 111.

‡ Members of the Senior Class in Dartmouth College.

"The summit of the (new) road (passing through the Notch to Portland, Maine,) is 835 feet above the plain of Colebrook. The direction of the pass is N.E. and S.W., and it is walled on both sides by towering ledges and pinnacles of mica slate, which stand nearly vertical, dipping to the N.W. 80°, and attain an elevation of 600 to 800 feet from the road"—of course about 1600 feet above Colebrook; and the Notch is parallel to the direction of the strata, which clearly have been removed on this line. Can we discover any disturbing agency or predisposing cause for this depression, from the summit of which the streams flow either way into the Androscoggin and the Connecticut? We learn that "dikes of basaltiform trap intersect the strata near the middle (summit?) of the Notch, and large loose blocks of it are seen in abundance on its northwest side. It contains very large crystals of basaltic hornblende and glassy white feldspar." The course of these dikes is not given. "On the north side of this road, forty or fifty rods back in the forest, is a ravine called 'the Flume.' It was formed by the decay of a large trap dike." "The chasm is twenty feet deep and from ten to twenty feet wide, and is the channel of a stream of water, from whence it received its name. The trap dike runs N. 30° E., and S. 30° W., and is six feet wide. It is slightly porphyritic with feldspar crystals, and is of a dark brown color. It divides into large cubical blocks which form a series of steps, so that when there is but little water a person may walk a considerable distance up the flume upon them. The principal ledge at this spot is granite, which protrudes through the mica slate."

Here we find a gorge through a mica slate range parallel with its direction N.E. and S.W., the slate dipping N.W. 80°, intersected by trap dikes—and near, another trap dike in a fissure, having the course N. 30° E., which is a variation of only 15° from the direction of the Notch, and all coincide in direction with the slate. But whether the different dikes are connected or not, erosion would seem to be indicated, down to the present level of the dikes, to the amount of 800 feet.

(*d.*) To cite one more case where the agent is still acting. The Waterqueechy river at Queechy village, (Hartford, Vt.,) makes a high fall of twenty feet over a dam of ten feet, and its rocky channel and sides are covered with pot-holes, and the gravel banks are here some eighty feet above with several terraces extending down a mile or more, where the narrow valley becomes a *cul de sac* from which the water could not have escaped before the present outlet existed, *except at a much higher level.** At this point the river enters a rocky channel, called "The Gulf," at a large angle with its previous course, and runs S.S.W. with a rapid descent for nearly a mile. The left bank (in the descent) is nearly vertical, though receding at top, and by estimate one hundred feet high, and the opposite bank, with various irregularities, is *in part* and in some places *entirely* made up of a *trap dike* from three to six and ten feet thick, whose course is N.N.E. and dip 58° southeasterly, and *coincident in these respects with the mica slate enclosing* and underlying it and parallel of course to the stream. It has here and there been crossed by the stream and extensively removed with the slate below it, and a channel has been made on both sides which is filled at high water; and again the dike is found enclosing the slate and is extremely hard and compact.

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* I am informed by the Rev. Mr. Dudley of the village, that between the gulf and the village there are two distinct deserted channels parallel to the present one, but much higher, where in all probability, the river once ran.

Passing off at right angles to this dike, as lateral branches, and crossing under the stream, are two other large vertical dikes which are very distinctly seen in section in the perpendicular wall of slate opposite, and they may be traced some distance easterly from the top of the bank, but are soon concealed by gravel and soil. One of these is twelve feet wide, of light blue color, and beautifully amygdaloidal, with numerous white crystallized balls.

These last dikes do not seem to have been injected subsequently to the first, but are so blended at their union with it, as to leave no doubt of their being one system, and a part of the trap network which extends through the region.

The pot-holes and troughs or elliptical holes, are very numerous throughout the channel as may be seen at low water, and they occur where there is no fall. They are produced by the action of a very rapid stream over an irregular surface. There can hardly be found a more satisfactory case of erosion by existing agencies. At the same time the trap dikes whose perpendicular section measures the extent of the specific action, indicate in their easterly extension, level with the surface of the enclosing rock of the bank above, the prevalence of earlier and more general superficial causes of denudation.

(*e.*) At the termination of the Mass. and Vt. Railroad near the Connecticut river bridge at Brattleboro, Vt., it was necessary to remove by blasting a large amount of slate rock, which was graded down about thirty feet to the level of the track, which is about thirty feet above the river. The whole of the surface of the rock laid bare, was very smooth, and worn into curves and channels and then scratched every where with strong marks, of varying north and south directions, parallel and crossing each other in groups. In this bank was a large trap dike thirty and more feet wide, whose surface was coincident with that of the slate and showed the same marks, continuous from one to the other.

The direction of the dike is about N.N.E. in a line with the bridge across the river, and it is quite probable the dike extends a long distance either way and was once a barrier to the river. The Connecticut river is here bounded on the east by a high rocky mountain, and the position and appearances of the dike in relation to the river, suggest the inference that the removal of the trap is a fair measure of the erosion at this place, and, at least in part, of that produced by the action of the river (sixty feet).

A small stream from the west in a deep rocky channel just north of the bluff removed, seems to have had its course deflected so as to empty into the Connecticut river just *north* of the intersection of the latter river and the dike, and their joint force has continued to reduce the level of the latter so as to afford the free passage of the river.

(*f.*) We may mention here, before proceeding, a few facts brought to light by the different railroad surveys in New Hampshire and Vermont. The Rutland and Burlington Railroad crosses the Green Mountains at Mount Holly gap, at a level of 1350 feet above the Connecticut river.* In this place a cut was made through a muck swamp, which exhumed some remarkable elephantine remains.† The White Mountain Railroad survey from the Connecticut up the Ammonoosuck, passes the summit in or near Whitefield, at six hundred and fifty feet above the Connecticut, and this within twelve miles of Fabyan's in the White Mountains. The Passumpsic Railroad overcomes the summit in Sutton at about nine hundred feet above the Connecticut at West Lebanon. The Central Railroad of Vermont passes the summit between the White and Winooski rivers near Montpelier, nine hundred and thirty feet above the Connecticut at West Lebanon. The Northern Railroad from Concord, New Hampshire, to the Connecticut, passes the summit between the Merrimack and Connecticut valleys, in Orange, with high grades of 52·80 feet in a mile on both sides, at an elevation of eight hundred and thirty feet above the Merrimack at Concord, and only six hundred and eighty-two feet above the Connecticut river on the west.

If at any time, by reason of the difference of level of these valleys of Connecticut and Merrimack rivers, water were discharged from one to the other for a long period through the lower passes, we should expect to have evidence of it engraved upon the rocks. If such evidences were discovered as we know from our running streams to be the effect of water, we shall be justified in referring them to a similar agency, i. e., water in motion. Should we observe phenomena like what are frequently seen, in the less rapid parts of a river and above dams in a rapid stream, we may refer their production to a similar cause.

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* See profiles and reports of these roads.

† Agassiz. Proceedings Am. Assoc. for Adv. Science, held at Cambridge, September 1, 1849.

The original features of this Orange summit were remarkable, but they have been very much altered by the cut for the railroad, which has however added, by the new features developed, very much to its geological interest. The facts have an important bearing on problems which are now arising with reference to the geological history of New England, and are therefore worthy of record. A description in part, is given by Dr. C. T. Jackson in the Geology of New Hampshire, p. 113.

The turnpike from Canaan on the northwest, passes some miles along the edge and on the sides of sand and gravel hills on the borders of an extensive swampy, peaty meadow, with a sandy bottom, which has long ramifications into the lateral valleys, then near a shallow pond of a few acres, which is fed by a rivulet coming from the hackmatac swamp at the base of the summit. The valley narrows rapidly, and towards the summit we find numerous long sand and gravel hills, shaped like an inverted boat, twenty to thirty feet high, parallel nearly to each other and to the general trend of the valley, with channels for surface water between them.

The depression or gap is several hundred feet below the general height of the range, and the old road formerly passed the summit at an elevation about forty feet above the swamp, and was made in the lowest channel cut by the waters formerly running here, and directly by the side of the "well"* made a slight descent across soft ground on a log causeway, then over a rocky ridge and down into Grafton valley.

This well or pot-hole, as figured, appears worn down on the side next the road three feet lower than on the opposite; its depth is eight feet; its diameter is between four and five feet at top, and about two feet at bottom. A large number of small, smooth rounded stones from this well, are in my possession, and in the Dartmouth cabinet is a plum shaped smooth mass of granite, which weighs two hundred and ninety pounds.

The surface of the rock wherever seen, even high above the road track is water-worn into cavities and channels descending to the southward, and great numbers of pot-holes have been uncovered, which have a tendency to a linear direction nearly north and south. In laying out the railroad, soundings were made between the two rocky barriers to the depth of near forty feet, in a peat bog, and the rock cutting was considerably diminished by laying the track about north and south, and obliterating wholly or in part many pot-holes of large and small size. Through the kindness of my friend, R. Bakewell, Esq., I refer to his drawing of the section made by the railroad on its west side.

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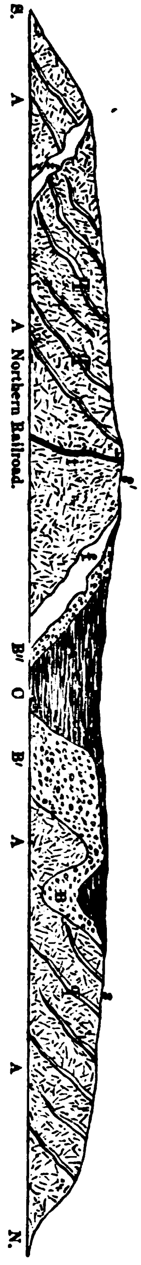
* Figured, Geol. N. H., p. 114.

The cut is north and south about 1600 feet long, and thirty-five feet deep; the railroad is at the base, and the former carriage road at the top.

A, granite, presenting two rocky barriers *s*, *s'*, the latter somewhat the highest:—these to the eastward rise more rapidly into ridges than on the west. The course of the channels in the granite is diagonal from the east side and descends south, showing certainly the direction of the stream. (*q*) Quartz veins from one to four inches thick, dipping from 35° to 42° S.E., intersecting the granite. These are cut off in barrier (*s'*) by two large veins (*f*) (*f'*), of whitish green feldspar with mica, and in some parts is handsome graphic granite, and all much harder and more difficult to excavate than the granite;—(*f*) is fifty-six feet wide and (*f'*) twenty-one feet. Their course is N. 18° E., and dip westerly 66°, and by the light color of the feldspar, they may be traced by the eye in a tortuous course far up the hills. B B' B'' are deposits without stratification, of fine and coarse gravel with large and small rounded pebbles covering the granite and extending somewhat lower than the track of the railroad; the portion B'' was made up chiefly of pebbles of the larger size, even one foot by one and one half foot. C is a bed or deposit of swamp muck, filling to the brim the excavation in the gravel and covering it from *s* to *s'*. This extends below the track, and east and west, and is some two hundred feet wide, in the line of section between B' B''. The draining of this swamp on the south, caused it to settle and tear apart in large patches, and to prevent its filling the track as fast as the excavations went on, a close row of piles thirty feet long was driven on each side and braced apart at top. Coniferous trees of considerable size, eighteen inches diameter, are found in this at all levels, prostrate and with roots attached, and also lying on stumps that were still in a vertical position; when cut they were found in the interior quite sound and of bright color. (*t*) Is a dike of gray amygdaloidal trap, three and one half feet wide. Its course is N. 30° E.; it was traced southwesterly up to the top of the ridge some hundreds of feet above



A, Granite.—B B'B'' Gravel, pebbles and sand—C, Peat containing trees and stumps—*f*,*f*,' Feldspar veins—*q*,*q*, Quartz veins—*s*,*s*', Summits. *t*, Trap dike.

the road, for a distance of near half a mile, where it is only one foot wide; it may also be traced some way on the eastward side of the road.

In my note-book are memoranda of pot-holes measured here, some of which (the last three) have been since in part removed.
1. 16 inches diameter and 4 feet deep.
2. 4 feet " and 4 " "
3. 3½ and 4 ft. " and 10 " "
4. 4½ feet " and 8 " "
5. 13 " " and 12 " " now less than a semicircle.
6. 5 " " and 8 " " a semicircle.
7. 8 " " and 10 " " in two curves, as if two holes had been worn into one.

No. 1, was filled with peat, and discovered by sounding with an iron bar; at a single blow the bar struck on the bottom a flattened, rounded smooth stone, of about four pounds weight, which was the last agent in the excavation of the hole. There is also a rocky channel some rods in length, oblique from the northeast, which is cut off by the railroad at its lower end; it is twelve feet wide and eleven feet deep, and contains near its mouth large rounded granite boulders from one to seven feet diameter. Such masses as these, with the great number of similar ones, large and rounded, in the portion of the gravel bed at B″, are proofs of the tumultuous action of a great body of water, by whose agency they were carried along into this whirlpool and revolved till they were rounded and often reduced to pebbles and powder, and thus removed to give place to others. At various stages in the process, some may have escaped from the excavations and were carried over the south summit (*s*), or were lodged on its north side.

The phenomena here presented, indicate a long continued discharge of a large current of water through this gap, from north to south, which has worn down the mountain range, hundreds of feet, as shown by the feldspathic veins, and especially by the *trap dike*, which was injected since the veins, as it cuts one of them. Similar circumstances must have been often repeated at higher levels, while this erosion was in progress. "The well" beside the road has been lowered three feet on one side, so as to form a channel in which the early road was made, while below this level it was perfect and eight feet deep. We may suppose, with reason, that these wells had been of similar dimensions through a long period while the action was going on, and that excavation below kept pace with the removal of the upper portion.

Between these two remarkable barriers on the north and south, the excavation in granite of this longitudinal valley is more than forty feet deep and six hundred feet wide; it has a very uneven surface, with rounded hummocks rising from the bottom, as shown on the E. and W. side of the railroad, in a section from eight to eighteen feet high above the track. On the north side it is filled with the accumulations of gravel, and on the south side the basin in this gravel is filled with a deposit of peat, containing abundance of prostrate trees apparently of successive generations.

The configuration of the excavated gravel shows the last result of moving water; the accumulation of the swamp muck and the growth of trees in this cavity are of course of subsequent date. The violence of the current which has here acted, may be inferred from the wearing effects exhibited on the rocks of the valley, S. and E., where they are smoothed and rounded at elevations far above the stream now flowing there; also from the great depth of Tewksbury Pond, and from the extensive beds of pebbles washed clean of all fine materials, sand and soil, in Danbury, about ten miles southeast.

Again—we see no evidence at present that these excavations and irregularities were produced by water *falling from a very great height;* they are rather the effect of a uniform though violent current; the same marks are seen in the slate and hard trap of the bed of the Queechy, where pot-holes and channels and capacious excavations long and deep are abundant as the effects of a rapid stream.*

If we may safely conclude that where numerous dikes, and these it may be in groups of six or eight, are found crossing in a valley a river channel, as at Campton Falls, N. H., and reduced to a level with its bed, with occasionally one harder than the rest forming a barrier of slight elevation, we have before us a present agency which in time past, may have been sufficient for the production of the degradation indicated by the extent of the valley. So when there are large, elevated areas yet far below the peaks and ridges of the country intersected in many directions by trap dikes and the whole surface worn smooth, we hesitate not to admit that a general denuding or erosive force has acted with energy and during a long period. When we find a mountain ridge cut at right angles by one or more trap dikes, and these reduced to an even surface with the crest and sides of the mountain, and continuous across the valleys, it is not easy for the mind to forbear concluding that the valleys are valleys of erosion, although they may be narrow and some thousands of feet deep. This is illustrated by the following cases.

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* In connection with these effects of larger currents, and in proof of their former existence in the channel of our present streams, I mention that a cut was made in West Hartford, Vt., on the Central Railroad, across the angle of a slate spur, about sixty feet above the White River, that opened a pot-hole to its bottom, seventeen feet deep and between three and four feet diameter. In this were found two beautifully rounded and smooth spheres of granite, one of which unfortunately was buried in the track, and the other, almost a perfect sphere, two feet four inches in diameter, and weighing over nine hundred pounds, is preserved for science at the University of Vermont at Burlington.

(*g.*) Moose Mountain is a part of a north and south range of mica and hornblende slates with quartzite. It is situated about eight miles east of Dartmouth College, and may be 1000 feet high. Between the granite knobs just east of the College and the range, there is a synclinal valley and axis, and the slates on Moose Mountain dip westerly at a high angle. In passing along the ridge some years since, I observed a depression eighteen feet wide with perpendicular sides twelve feet high, and this singular interruption of the line of the ridge led to an examination of the rock in this space. It proved to be a dike of columnar porphyritic trap running east and west, which was traceable some way down the declivity, but of a uniform surface with the sides of the mountain.

On the opposite side of the valley, and crossing it and the road obliquely and following exactly the undulating and channeled surface of the slate, is another very compact, hard, blue trap dike, with crystals of glassy feldspar, and fourteen feet wide. These dikes if produced must intersect each other, and the latter is cut down many feet by a small stream.

A few miles south where this ridge is interrupted by the valley of the Mascomey River or Enfield Pond, the precipitous bluff presents a dike some feet in width which is made up of flattened and rounded masses of trap in columns side by side, and rapidly decomposing. This is one hundred feet and more above the level of the lake, which is at the base of the ridge, and whose bed must be intersected by the dike.

(*h.*) Mount Washington, as I showed in the American Journal, xxxiv, in 1838, is covered or capped with mica slate *in place*—and as there is no evidence from diluvial scratches, boulders or rounded and smooth surfaces, of erosion or denuding forces, we infer that its peak ever has been above the reach of those agencies which have operated upon its flanks and upon the surrounding peaks.

If a fissure should occur through one of these granitic peaks from valley to valley, (it would probably be much farther extended,) and if molten lava were to fill this fissure, it could never reach the apex or remain consolidated there, unless it were supported at the *limits* of the fissure on the flanks of the mountain. It is contrary to physical laws that as the lava rose in the fissure, it should not gravitate and run into the lower places, the valleys on the sides of the mountain, and only as these were filled would it rise in the fissure, and equally in both. This must follow whether the surface be submarine or subaerial.

1. If the existing valleys were filled to the height of the peak with *diluvium* or *drift*, like the conglomerate hardpan of this region, which is so consolidated that when excavated it must be blasted, this would seem sufficient to repress or hold up the col-

umn of lava and secure a uniform dike to the full height of the peak. The hardpan would be fissured and the dike found continuous through it; but this supposition implies a *previous excavation or erosion of the valleys.*

2. If existing valleys were formerly filled with *trap* by an overflow from the fissure, they are now clear of it and have been reduced to their former condition, i. e., they have been excavated a *second time as in the former case.*

3. If the present valleys were formerly occupied by continuous rock, such as constitutes the mountains, then a support is had for the molten lava when injected to the height of the peak, so as to allow the filling of the fissure and to form a dike; and the present configuration is the result of a subsequent erosion or excavation. Whether these valleys, therefore, were ever filled with diluvium or trap, need not be shown, as we must in that case, at a previous time introduce the latter supposition, involving as it does only a single excavation.

There is a possible supposition that the valleys of the White Mountains are the result of fracture and subsidence of their areas —or of fracture and elevation of the ridges—but I know of no evidence of this, and where the rock can be traced across from side to side of a valley, the continuity is complete. To sustain the third view above, I cite the following facts.

Mount Pleasant, the third peak south of Mount Washington, is about 4500 feet high. Its top is a plain of five or six acres, so even and level that a horse may be galloped all about upon it.

It is intersected near its center by a dike of very hard, bluish trap three feet wide, whose course is east and west, which is worn off entirely smooth and level with the enclosing rock, and may be traced entirely across the top. Circumstances did not allow an examination for its continuance beyond these limits, where the sides of the mountain are covered; but by telescopic examination from Fabyan's, which showed distinctly the little column of trap fragments piled upon the dike of two feet in height, I was led to infer a probable relation between the dike and the slides on the west side of Mount Pleasant, which seemed to be in the range with it. However this may be, the dike must be considered for the reasons already given, as of much greater length than the crest of the mountain and of course extending down into or across the valleys.

Though the positive evidence may be wanting of this latter point, yet from a party of our students who, in the autumn of 1848, descended into the valley on the east side of Mount Pleasant, from directly opposite the "Lake of the Clouds," and followed the mountain stream throughout its course of falls and rapids, &c., to the valley of Dry river, and down this to its junction with the Saco in the Notch, two or three miles below the

Willey House, and some twelve miles from where they began the descent—I learn that "two or three miles above the mouth of Dry river there are several remarkable trap dikes at right angles to, and crossing the stream, and running up into the mountain on the sides; one of them is five or six feet wide and is smooth and even with the rock enclosing it, and the stream makes a nearly perpendicular plunge at this point, of eight or ten feet,"—thus presenting such phenomena as are common in other similar places, and as ought to be found constantly existing or repeated in a process of excavating a valley by a running stream.

The facts which I have recorded, showing the relations between trap dikes, which have been denuded and eroded to considerable depths by running streams, will need no comment or illustration.

In regard, however, to such cases as Mount Pleasant and Moose Mountain, where no running water is found, we must recur to the periods when the relations of land and water were very different from the present.

We are too much disposed to look upon the great features of this group of mountains as fixed so long ago as to have no connection with the minor ones now presented, and which are in process of increase. The agencies of decomposition are now at work on a scale of sufficient magnitude to produce great changes in a generation, and the accumulation of debris since August, 1826, at the gorge back of the Willey House, and in the outlets of the two below it, if we could add also the large amount of fine materials carried down stream by the Saco from these sources, are well calculated to prevent our underestimating their importance.

The gorge ½ a mile below the Willey House being in the line of some trap dikes cutting the mountain, is already a very considerable depression, and in imagination we may anticipate the time when it has become a separating valley two or three thousand feet deep, like the one east of Mount Pleasant. We have only to extend this view to the thousands of precipitous torrents, and the more advanced channels, to provide for the future intersection of these ranges, and, as the valleys are deepened and widened, for their more rapid destruction by undermining and slides. It is not my object to exclude by any means the general operation of any or all of the authentic agencies, whether marine or freshwater or others subordinate, that by future observation may be shown to have left their impress on this region—but while observation shows a very considerable erosion of these valleys and mountains now going on, I wish to present other facts which lead to the conclusion, that these *deepest valleys are but valleys of erosion.*

The examination of the valleys of the state of New York, as at the Little Falls, &c., and of its lakes in different parts, shows a difference of level and a depth of erosion of 1200 feet to 2000 feet. So also the observations on the sandstone of the Connecticut valley in Massachusetts and Connecticut, indicate its erosion to the extent of 1200 feet. This erosion of the sandstone is only consistent with a similar one in the northern portions of New England, and requires its occurrence if we would provide the constituents of the sandstone in the first place and its continuance and increase subsequently. Whether this result is referable to one period or another is not now a question.

The following facts are cited from the Report of the Geology of New Hampshire, to sustain the general proposition, and which is also strengthened by the evidence afforded by metallic veins in positions similar to that of the trap.

1. The Lower Patuccoway Mountain of syenite in Nottingham is cut, through its summit, into two nearly equal parts by a dike of columnar greenstone trap from six to twelve inches wide, and which can be traced for a quarter of a mile till concealed by the soil. This mountain is 780 feet high above the sea.

2. In Piermont the mica slate is intersected by numerous dikes of greenstone trap; and from Piermont to Haverhill Corner, nine dikes are found, some of them porphyritic, and one so filled with magnetic iron pyrites as to affect the compass.

3. Red Hill, of syenite, and 2000 feet above the level of the sea, is crossed at about one-third its height by a large dike of porphyritic trap, N. 30° W.

4. On the declivity of the westerly peak of Gunstock Mountain, which is 1561 feet above lake Winipissiogee, is a vein of magnetic oxyd of iron, the pieces of which have polarity, and large dikes of trap occur on the southerly peak.

5. Baldface Mountain, in Jackson, of granite, is cut through its midst by a few trap dikes, and at a height of 1404 feet above its base, and in other places is cut by veins of peroxyd of iron of great width, which are traced down its flanks.

6. Several trap dikes in Jackson contain carbonate of lime, and cut through mica slate, granite and a granite vein, one of which is fifty feet wide.

7. At Hampton Falls, and on to the sea, the hard flinty rock is cut by dikes of trap.

8. In Eaton, dikes of porphyritic trap from ten to sixteen feet wide cut through a hill of granite, and again in another place a trap dike four feet wide cuts a hill of granite.

9. On the east flank of the White Mountains, on the Pinkham road in Jackson, the mountain ledge of mica and chiastolite slate

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1. p. 50.—2. p. 65.—3. p. 71.—4. p. 72.—5. pp. 78, 79.—6. p. 80.—7. p. 93.—8. pp. 95, 98.—9. p. 99.

is cut by two large trap dikes, and Town's hill in Lancaster, is intersected by trap dikes in limestone.

10. Trap dikes, porphyritic and dark brown compact, occur at Berlin Falls, and are also found in passing from Berlin to Lancaster.

11. In Littleton are trap dikes cutting mica slate.

12. Thorn Mountain, in Jackson, consisting of a porphyry, is cut through at top by veins of magnetic oxyd of iron descending its flanks, and by a dike of basalt.

These examples of trap are at very various heights above the sea, and are a fair illustration of the amount of erosion of the rocks in their several localities. I know of no more valid objection to the conclusions based on the evidence afforded by the relations of the trap in New Hampshire, than would lie against those derived from the trap in other formations, whether in the mountains of northern New York or in the coal formation, or in the sandstones of all countries; and future examination in the very instructive geological field of the White Mountains will doubtless furnish much more similar evidence.

ART. XIX.—*Contributions to the Mycology of North America;* by Rev. M. J. BERKELEY, of England, and Rev. M. A. CURTIS, of South Carolina.

61. **AGARICUS ANTILLARUM**, Fries.—In fimetis. May–Nov. Society Hill, S. Carolina.

62. **COPRINUS TERGIVERSANS**, Fr.—Ad terram. Dec. Santee Canal, S. C. Mr. Ravenel.

63. **PAXILLUS POROSUS**, Berk.! in Lea's Catalogue.—Ohio! Mr. Lea. S. Car.! In sylvis humidis. Aug.–Oct.

64. **HYGROPHORUS MUCILAGINOSUS**, Berk. and Curt.;—pileo valde mucilaginoso lætecolori convexo demum plano striato; stipite fragili subconcolori fistuloso; lamellis decurrentibus crassis carneis. In paludosis. July. Society Hill.

Cap 6–9 lines broad, of a bright pale reddish yellow, darker in the centre. Stem ½ inch high, a line or more thick, composed of longitudinal fibres, subpellucid, pale yellow or carneous. Gills distant, unequal, fleshy. Allied to *H. Cantharellus*, Fr., from which it is readily distinguished by its very mucilaginous pileus and thick gills; and from *H. lætus*, Fr., by its brittle stem.

65. H. **LURIDUS**, Berk. and Curt.;—pileo campanulato umbonato pallide fusco viscosissimo; margine striato crenato; stipite

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10. p. 104.—11. p. 109.—12. p. 145.

fistuloso concolori; lamellis crassis venoso-connexis adnexis albis. In paludosis. July. Society Hill.

Cap 7–9 lines broad, pale brown, darker in the centre. Stipe 1½ in. long, about a line in thickness, composed of longitudinal fibres. Gills ventricose, shortly adnate. Not very closely allied to any species described, except perhaps to *H. unguinosus*, which is however more robust and of different habit.

66. H. COCCINELLUS, Fr.—In terra arenosa humida. Aug. Society Hill.

67. H. CHLOROPHANUS, Fr.—Ad terram inter folia. June. Hillsborough, N. Car.

68. LACTARIUS INSULSUS, Fr.—Ad terram in sylvis. Aestate. Hillsborough, N. C.

Agaricus fuliginosus, *vellereus*, and *camphoratus*, enumerated in a previous paper, belong to this genus.

69. CANTHARELLUS UMBONATUS, Fr.—In sylvis. Oct. R. Island. Mr. Olney.

70. MARASMIUS OPACUS, Berk. and Curt.;—gracilis; pileo convexo ruguloso opaco pulverulento albido; stipite insititio elongato pulverulento-subfurfuraceo pallido; lamellis ventricosis distantibus adnexis. Ad ramulos et folia dejecta in sylvis. Aestate. Society Hill and Santee Canal, S. Car.

Cap about 2 lines broad, sometimes slightly depressed around a central umbo, dirty-white, scarcely striate or sulcate. Stem 1–1½ inch. high, ⅛ of a line thick, of the same color with the cap, furfuraceous toward the base. Gills moderately broad, slightly adnate, with the interstices nearly even. Nearly allied to *M. ramealis*, but, like *M. synodicus*, is far more elongated. From the latter it differs in its rather broad, not vein-like gills; and from *M. candidus*, in its opake pileus.

71. M. PITHYOPHILUS, Berk. and Curt.;—pileo e convexo plano-umbilicato sulcato-striato brunneolo; stipite insititio solido concolore pulverulento-furfuraceo; lamellis fusco-carneis subdecurrentibus. Ad folia Pinea dejecta. July. Society Hill.

Cap 4 lines broad, impressed-striate, dry, submembranaceous, whitish-brown. Stipe ½ in. long, scarcely ½ line thick, firm, subequal, pale or brownish pulverulent, clothed toward the base with minute furfuraceous scales. Gills unequal, forked, undulated. Agrees in habit with *M. fœtens*, but the stem is more opake, and the gills are by no means annulato-adnexed.

72. M. SPONGIOSUS, Berk. and Curt.;—pileo plano albido-fusco; stipite pulverulento basi incrassato spongioso fulvo-villoso; lamellis albidis subconfertis. Inter folia putrescentia in humidis. June, July. Hillsborough, N. C. and Society Hill, S. C.

Cap 4–6 lines broad, darker in the centre, obtuse. Stem 1½ in. long, brown, often much twisted, thickened toward the base and clothed with a tawny villus. Has much the aspect of *M. plancus.*

73. M. SIMILIS, Berk. and Curt.;—pileo membranaceo plicato opaco albido; stipite gracili elongato nitido fusco; lamellis paucis latis adnexis venoso-connexis albidis. Ad terram. July, Aug. Society Hill.

Gregarious. Cap 2–3 lines broad, dull white, smooth, covered with minute wrinkles. Stem 2 in. long, very slender, hardly pulverulent. Gills ventricose. Allied to *M. hæmatocephalus,* Fr., from which it is easily distinguished, at least by color.

M. hæmatocephalus, (No. 2 of these Contributions,) I find also at Society Hill, S. C.; sometimes having a stem 3 in. long with a cap 12–15 lines broad. Mr. Olney has also sent it from Rhode Island.

74. M. GRAMINUM, Berk.!—Ad folia graminum, herbas, etc. in hortis. June. Society Hill.

75. M. VAILLANTII, Fr.—Ad cortices emortuos, e. g. Vitis. Aug. N. and S. Car.

76. M. PLANCUS, Fr.—In sylvis acerosis. R. Island; Mr. Olney.

77. LENTINUS RAVENELII, Berk. and Curt.;—pileo umbilicato submembranaceo striato squamuloso maculato; stipite curto tenui furfuraceo-squamoso; lamellis tenuibus subdistantibus dente-decurrentibus venoso-connexis. Ad lignum putridum in humidis. April. Santee Canal, S. C. Mr. Ravenel.

Scattered. Cap 1–1½ in. broad, plano-convex, white, clothed with minute rufous velvety scales which are crowded and confluent in the centre. Stem 1 in. long, 1 line thick, solid, white, with rufous scales. Gills white, slightly erose. A very pretty species allied to *L. tigrinus,* but much more delicate. The pileus is thin, and in consequence when dry it has an hygrophanous aspect.

78. L. CESPITOSUS, Berk.! in Lea's Catalogue.—Very abundant in N. and S. Car: from July to Nov.; at the base of stumps and on buried roots. When dry it has a kind of acid-sweetish odor not unlike that about a cider-press.

79. PANUS DORSALIS, Fr.—Ad lignum mortuum Pini [et Liquidambaris?] Autumno, Hieme. N. and S. Car.

80. XEROTUS DEGENER, Fr.—Ad terram argillaceam inter muscos. June. Hillsborough, N. C.

81. LENZITES UNGULÆFORMIS, Berk. and Curt.;—albida lignea subtriquetra inæquabilis glabrata nitida; lamellis ligneis latis poroso-ramosis.—Ad lignum aridum. Wilmington, N. Car.

Cap 2 in. broad, 1¼ in. long, ¾ thick, rather elongated, villous when young but becoming smooth and shining; surface unequal, once or twice sulcate, with some trace of almost obliterated villosity towards the margin. Gills broad, thin but woody, branched, and here and there forming sinuous pores.—Allied to *L. betulina*, but more rigid. It also resembles *L. aspera*, but has not the scabrous surface of that species, nor has it the same habit.

82. L. TRICOLOR, Fr.—Ad ramos dejectos in sylvis humidis.—N. and S. C. Item, R. Island. Mr. Metcalf.

83. L. KLOTSCHII, Berk.!—Ad truncos dejectos. Oct.–March. N. and S. Car. Item, R. Island. Mr. Bennett.

84. L. STRIATA, Fr.—Ad lignum aridum. Society Hill and Santee Canal, S. Car.

85. L. CORRUGATA, Fr.—Ad ramos Castaneæ. R. Island. Mr. Metcalf; Mr. Bennett.

86. BOLETUS ELEGANS, Schum.—Ad terram. Aestate. Hillsborough, N. C.

87. B. VERSIPELLIS, Fr.—Ad terram. Aug. Hillsborough, N. C.

88. B. RUBIGINOSUS, Retz.—Ad terram in sylvis. Sept. Hillsborough. N. C.

89. POLYPORUS ARCULARIUS, Fr.—Ad ramos dejectos in humidis. May. Raleigh, N. C.

90. P. BOUCHEANUS, Fr.—Ad ligna. July, Aug. Hillsborough, N. C. Item, Ohio! Mr. Lea; and Penn Yan, N. Y.! Dr. Sartwell.

91. P. CURTISII, Berk.;—pileo excentrico molli-suberoso sulcato zonato ochroleuco hic illic sanguineo-laccato; stipite elongato rugoso sanguineo-laccato; hymenio ex albo ochraceo; poris punctiformibus.—Ad basin truncorum. N. and S. Car.

Cap 3–5 in. broad, convex, more or less grooved and zoned, of a rather soft corky texture, covered with an ochraceous often opake laccate crust which in parts is sometimes sanguineous. Substance toward the tubes cinnamon, above ochraceous, not zoned, traversed with laccate lines parallel to the surface. Margin obtuse. Stipe 2–5 in. long, ½–1 in. thick, uneven, shining. Hymenium white becoming ochraceous and brownish-cinnamon, sometimes partly laccate. Pores not angular, cinnamon colored, stratose within.—This fine species is closely allied to *P. lucidus*, but differs as above. It has also some resemblance to *P. ochreo-laccatus*. Mont.

92. P. ELEGANS, Fr.—Ad terram. Aug. R. Island. Messrs. Metcalf and Bennett.

93. P. PES-CAPRÆ, Pers.—Ad terram in montosis. Hillsborough, N. C.

94. P. LOBATUS, Fr.—Ad lignum in terra. Hillsborough, N. C. Item, Santee Canal! S. C. et in Georgia! Mr. Ravenel.—Habet odorem fortem farinæ recentis.

95. P. (Anodermei) CAROLINIENSIS, Berk. and Curt.;—pileo molli-suberoso reflexo postice effuso inæquabili ochraceo-albido subsericeo strigis innatis asperulo subzonato; poris mediis dentatis acie plus minus lacerata.—Ad truncos emortuos Quercus [et Liriodendri?] Autumno, Hieme. S. Car.

Pileus 2–5 in. broad, ½–2 in. long, much effused behind, sometimes nearly resupinate, of a soft corky texture, rugose, slightly silky with innate or raised strigæ which sometimes project from the surface, sometimes nearly smooth with innate fibrillæ; margin acute. Pores of the same color with the cap, middle sized, $\frac{1}{36}$ of an inch broad, dissepiments thin and often broken up; sometimes the edge of the pores is obtuse.—Resembling *P. borealis*, Fr., and *P. Symphyton*, Schwein., of a looser texture than either, and with larger pores than the former.

96. P. (Placodermei) PALUSTRIS, Berk. and Curt.;—pileo carnoso-suberoso dimidiato obtusissimo cute tenui rivulosa nitidiuscula vestito; poris niveis non stratosis minutis angulatis.—Ad Pinum palustrem. Santee Canal. Ravenel.

Pileus 2 in. broad, 1 long, ½ thick, subungulate, clothed with a thin rather shining cracked ochraceous cuticle. Substance white uniform. Pores about two lines long, minute, white within and without, not at all stratose, slightly angular, with thin dissepiments and rather irregular edge.—Nearly allied to *P. officinalis*, but the pores are smaller, pure white, and not at all stratose; nor is the flesh bitter when dry or easily reduced to powder.

97. P. SALICINUS, Fr.—Ad truncos putridos. Santee Canal. Ravenel.

98. P. CARNEUS, Nees.—Ad palos. June. Society Hill.

99. P. (Placodermei) CUPULÆFORMIS, Berk. and Curt.;—pileo pezizæformi e vertice elongato stipitato albido cinnamomeo puberulo; hymenio plano-excavato cinnamomeo; poris minutis. —Ad corticem Rhois copallinæ; S. Car. Castaneæ; R. Island! Mr. Olney. Vere.

Gregarious. Cap 1–1½ line broad, attached by the vertex which is elongated into a short stem, cinnamon clouded with grey, slightly downy. Hymenium sunk below the swollen margin. Pores very minute.—Allied to *P. pullus*. Mont. and Berk.

100. P. (Inodermei) XALAPENSIS, Berk.;—pileo flabelliformi membranaceo zonato sericeo glabrescente; poris parvis dissepimentis tenuibus membranaceis hydnoideo-laceratis.—Ad ramos dejectos cariosos. Oct. Society Hill.

Cap thin, variously lobed, 2–4 in. long, pale, silky, at length nearly smooth and shining, repeatedly but delicately zoned. Hymenium white; dissepiments becoming soon torn and toothed so as to give the appearance of a Hydnum.—Closely allied to *P. elongatus*, Berk.—This species was first discovered in Xalapa by Mr. Harris.

Art. XX.—*Connection between the Atomic weights and the physical and chemical properties of Barium, Strontium, Calcium and Magnesium, and some of their Compounds;* by E. N. Horsford, Rumford Professor in the University at Cambridge.

Read before the Cambridge Scientific Association.[*]

The great discovery of isomorphism by Mitscherlich,[†] and the affiliated one by Kopp,[‡] of the identity of the specific volumes of isomorphous bodies are among the brilliant points in the progress of the chemistry of this century.

The latter seems to have had its origin in a conviction that in the atomic weight of a body—all its attributes have what may be denominated a *product expression.* The factors are *form, volume* and *density.* Each may vary, and with it the atomic weight will vary; for example:—the volume and form being constant, increase of density will be accompanied by increase of atomic weight: or form being constant, increase of density will be accompanied by increase of atomic weight, or, density and volume being constant, modification of form will influence the atomic weight.

The object of the following paper is to show that the properties of the metals, barium, strontium, calcium and magnesium, and of their compounds generally, are, in their intensity, in the order of their atomic weights. It will be seen that the law is more true of the first three than of these taken in connection with the fourth.[§]

The signification of the term intensity, as used above, may be thus illustrated. Sulphate of baryta requires 43000 parts of water for its solution. Sulphate of strontia 15029 parts at 11° C.[‖] Sulphate of lime ($CaO, SO_3, 2HO$) in 380 parts of cold water, and 388 parts of hot water,[¶] and sulphate of magnesia with seven atoms of water, 0·799 parts at 18·75°.[**]

	Solubility.	At. W.
BaO, SO_3	43000·00	116·5
SrO, SO_3	15029·00	91·7
CaO, SO_3	460·00	68·
MgO, SO_3	0·79	60·7

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[*] A summary of some of the conclusions arrived at by the author were communicated to the American Association of Geologists and Naturalists, at their meeting in Boston in 1849.

[†] Ann. Chim. Phys., xiv, 172; xix, 350; xxiv, 264, 265. Pogg. Ann., xii, 137; xxv, 300; xlix, 401.

[‡] Pogg. Ann., xlvii, 132; lii, 243–262. Ann. Chem. u. Phar., xxxvi, 1.

[§] It is to be regretted that so little is known of the properties of the compounds of magnesia. Their eminent solubility in water, and the difficulty with which any of the salts of this base may be made to crystallize, have made this field of investigation less inviting than many others.

[‖] Brandes u. Silber, Br. Arch., xxxiii, 61.

[¶] Giese. According to Bucholz, 480 parts cold or hot.

[**] Gay Lussac. The anhydrous sulphate is soluble at 0° C. in 3·885 parts of water.

Here *intensity* is the same as *degree of solubility.* In other words, the solubilities of the above salts are in the order of their atomic weights.

The truth of the general proposition will be apparent from considering the following facts.

I. Barium unites with two atoms of oxygen, and is stable in this state of combination at ordinary temperatures.*

Strontium and calcium peroxyds are only known in combination with water.†

Magnesium combined with two atoms of oxygen is unknown.

II. Barium, strontium and calcium all oxydate at ordinary temperatures in the air.

Magnesium does not.

III. Barium thrown into water causes decomposition with a stormy evolution of hydrogen gas.

Strontium and calcium are both dissolved with escape of hydrogen.

Magnesium may be washed in water that has been thoroughly freed from air by boiling, without diminution of its lustre.

IV. Baryta moistened with water enters into combination with it, attended by such evolution of heat as melts the hydrate formed.‡

Strontia falls with water to a white pulverulent hydrate, with the production of intense heat. Lime similarly treated yields a heat that will fire sulphur.§

Magnesia in uniting with water is but slightly heated.‖

V. Hydrate of baryta loses none of its water under intense red heat.¶

Hydrate of strontia, by long continued red heat, melts, and by higher heat loses all its water.**

Hydrate of lime, by moderate red heat without melting, loses its water.

Hydrate of magnesia loses its water below the red heat.

VI. Carbonate of baryta, an hour and a half exposed to the most effective blast furnace heat, loses its carbonic acid.††

Carbonate of strontia, loses its carbonic acid in the strong heat of an open fire.‡‡

Carbonate of lime is decomposed at a red heat.

Carbonate of magnesia loses its carbonic acid at a moderate red heat.

VII. Selenite of baryta and selenite of strontia are insoluble in water.

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* Thenard. Ann. Chem. Phys., viii, 308. Rammelsberg, Pogg., xliv, 558.

† Thenard. Ann. Chem. Phys., viii, 313.

‡ Döbereiner. Schw., vi, 367.

§ Ann. Chem. Phys., xxiii, 217.

‖ H. Davy.

¶ Bucholz u. Gehlen, iv, 258.

** Denham Smith. Phil. Mag., ix, 87. Pogg., xxxix, 196.

†† Abich, Pogg., xiii, 314.

‡‡ Ibid, 315.

Selenite of lime and selenite of magnesia are slightly soluble in water.

VIII. Biselenite of baryta dissolves with difficulty in water.

The same is true of the corresponding salts of strontia and lime.

Biselenite of magnesia is a doughy deliquescent uncrystallizable salt.

IX. Selenate of baryta is as little soluble as the sulphate.[*]

Selenate of magnesia is equal in solubility to the sulphate.[†]

X. Iodid of barium crystallized with an atom of water, is readily soluble in water, but does not deliquesce upon exposure to the air.[‡] It is deliquescent.[§] It is not fusible.

Iodid of strontium is readily soluble in water.[‖] It is fusible below red heat.

Hydrated iodid of calcium may be crystallized. It deliquesces on exposure to the air,[¶] and fuses below red heat.

Hydrated iodid of magnesium crystallizes with difficulty, and deliquesces readily.

All decompose, when heated by access of air, into metallic oxyds.

XI. Iodate of baryta with one atom of water is soluble in 1746 parts of water at 15° C. and in 600 of boiling water.[**]

Iodate of strontia with six atoms of water is soluble in 342 parts of water at 15° and in 110 of boiling water.[††]

Iodate of lime with five atoms of water dissolves in 253 parts of water at 15° C. and in one hundred and ten parts of boiling water.[‡‡]

Iodate of magnesia is soluble in water, but has not been further examined.

XII. Bromid of barium with two atoms of water is unaffected by exposure to air.

Bromid of strontium with six atoms of water loses its water at a feeble heat.[§§]

Anhydrous bromid of calcium deliquesces rapidly in the air. That with one atom of water crystallizes with difficulty from the solution of bromid of calcium.

XIII. Bromates of baryta, strontia, lime and magnesia crystallize with water, the first three with a single atom.

Bromate of baryta loses its atom of water not below 200° C.

Bromate of strontia by 120° C., bromate of lime by 180° C. and bromate of magnesia at ordinary temperatures.

XIV. Bromate of baryta dissolves in 130 parts of cold water.

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[*] Berz. Pogg., xxxii, 11.

[†] Berz. Schw., xxiii, 454.

[‡] Gay Lussac.

[§] O. Henry.

[‖] Gay Lussac.

[¶] Berthemot. J. Pharm., xiii, 416.

[**] Rammelsberg.

[††] Ibid.

[‡‡] Ibid.

[§§] Löwig.

Bromate of strontia in three parts; bromate of lime in 1·1 parts, and bromate of magnesia in 1·4 parts.*

XV. When chlorid of barium is formed by leading the vapor of hydrochloric acid over heated baryta, the decomposition is attended with the evolution of heat and a red light. The same phenomena occur in the similar production of chlorid of strontium.

That of chlorid of calcium is attended with heat only.

Chlorid of magnesium cannot be formed in this manner.

XVI. The specific gravity of anhydrous chlorid of barium is 3·7037, of chlorid of strontium 2·8033, of chlorid of calcium 2·0401.†

XVII. When heated in dry air, chlorids of barium, strontium and calcium become alkaline; while chlorid of magnesium remains unchanged.

XVIII. Crystallized chlorids of barium and strontium do not change upon exposure to the air.

The chlorids of calcium and magnesium deliquesce rapidly upon exposure to the air.

XIX. Chlorid of barium is soluble in from 8108–6885 parts of cold alcohol, of 99·3 per ct., and in 4875 parts of boiling alcohol.

Chlorid of strontium is soluble in from 116·4–111·6 parts of cold and in 262 parts of boiling alcohol of 99·3 per ct.‡

XX. Chlorate of baryta requires four parts of water for its solution.

Chlorates of strontia, lime and magnesia deliquesce in the air.

XXI. Chlorate of baryta is insoluble in alcohol.

Chlorates of strontia, lime and magnesia are soluble in alcohol.

XXII. Fluorid of barium is readily soluble in hydrochloric and nitric acids.

Fluorid of calcium is slightly soluble in boiling acids, and fluorid of magnesium scarcely at all in cold or hot acids.

XXIII. Fluorid of barium is soluble in aqueous hydrofluoric acid; fluorid of strontium less; fluorid of calcium a mere trace, and fluorid of magnesium not at all.

XXIV. Nitrites of baryta and strontia do not change in air.

Nitrites of lime and magnesia deliquesce upon exposure to the air.§

XXV. Nitrate of baryta requires 20 parts of water at 0° for solution. Nitrate of strontia 5 parts of cold water. Nitrates of lime and magnesia deliquesce most rapidly in the air.

XXVI. Nitrates of baryta and strontia are not soluble in alcohol. Nitrates of lime and magnesia are soluble.

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* Rammelsberg. Pogg. Ann., lii, 81.

† Karsten.

‡ Fresenius. Liebig's Ann., Bd. lix. 117–128.

§ Mitscherlich.

XXVII. Carbonate of baryta is soluble in 14137 parts of cold, in 15421 of boiling water. Carbonate of strontia in 18045 parts cold water. Carbonate of lime in 10601 of cold and 8834 of boiling water.[*]

XXVIII. Oxalate of baryta with one atom of water is soluble in 200 parts of cold or boiling water.[†]

Oxalate of strontia with one atom of water is insoluble in water[‡]—even in boiling water.[§]

Oxalate of magnesia with two atoms of water only very slightly soluble in water.[‖]

XXIX. Formiate of baryta is soluble in 4 parts of cold water.[¶]

Formiate of lime in 8 parts of cold and in 10 parts at 19° C.[**]

Formiate of magnesia is soluble in 13 parts of cold water.[††]

XXX. Sulphovinate of baryta is soluble in 0·92 parts of water at 17° C.[‡‡]

Sulphovinate of lime is soluble in 0·8 parts of water at 17° C.[§§]

XXXI. Acid urate of baryta is insoluble in water. That of strontia somewhat soluble in hot water. That of lime of difficult solubility. That of magnesia, is soluble in 3500–4000 parts of cold and 150–170 parts of boiling water.[‖‖]

XXXII. Neutral alloxanate of baryta is less soluble than the corresponding salts of lime and magnesia.

XXXIII. The above salts of lime and magnesia are somewhat soluble in alcohol. The salt of baryta is not.[¶¶]

XXXIV. Ferrocyanid of barium ($Ba_2Fe\,Cy_3$) dissolves in 584 parts cold,[***] 1800,[†††] and in 116 parts of boiling water.[‡‡‡]

Ferrocyanid of strontium dissolves in 2 parts of cold and 1 of boiling water.[§§§]

Ferrocyanid of calcium deliquesces in the air.[‖‖‖]

Ferrocyanid of magnesium with 12 atoms of water dissolves in 3 parts of water.[¶¶¶]

It is to be regretted that other properties, including specific gravity, specific heat and light-refracting and heat-conducting power have been so little studied. Still, enough of correspondence and gradation among the properties of the compounds of this group has been shown to establish the general proposition that the intensities of their chemical attributes are in the order of the atomic weights of the metals, and lead to the conviction that other attributes might be found to be in similar gradation of intensity.

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[*] Fresenius. Liebig's Ann., Bd. lix, s. 117–128.

[†] Bucholz. Taschenbuch, 18. 18.

[‡] Scheele.

[§] Wackenroder.

[‖] Graham.

[¶] Arvidson.

[**] Gobel.

[††] Arvidson.

[‡‡] Magnus.

[§§] Marchand.

[‖‖] Bensch. Liebig's Ann., liv, 189–208.

[¶¶] Schlieper, Liebig's Ann., Bd. lv, s. 272-279.

[***] Dufloe.

[†††] Porret.

[‡‡‡] Dufloe.

[§§§] Bette. Ann. Pharm., xxviii, s. 54.

[‖‖‖] Ittner.

[¶¶¶] Bette. Ann. Pharm., xxii, s. 152; xxiii, s. 115.

The resistance to the passage of an electric current through the fluid solutions of these bodies might, it was conceived, be in the order of their atomic weights.

To ascertain if this supposition were founded, an apparatus was employed an account of which has been published in my paper upon the resistance of fluids to electric conduction,* and may be referred to here, as a perusal of this description will be necessary in order to the appreciation of the application of the law.

The fluids employed were nitrates, hydrochlorates and acetates of baryta, strontia, lime and magnesia.

The baryta and strontia salts were prepared from the sulphids (derived from the native sulphates by reduction with charcoal and rye meal); the lime salts from the hydrate, and the magnesia salts from magnesia alba.

The barium and strontium sulphids were dissolved in the several acids with slight excess of acid filtered, neutralized by addition of hydrates of baryta and strontia to the respective solutions, concentrated by evaporation, crystallized, and the crystals washed and dissolved.

The hydrate of lime was dissolved in the several acids, the solutions kept alkaline by excess of lime to precipitate the iron, filtered, and accurately neutralized.

The magnesia alba, with the aid of heat, was dissolved in the several acids and carefully neutralized.

A saturated solution of chlorid of barium, the least soluble of the salts employed, at 16° C., had a specific gravity of 1·042. The solutions of the other chlorids and remaining salts were with great care brought to the same degree of dilution. Two series of results were obtained with the solutions of chlorid of barium and chlorid of strontium. The series in column I. were with solutions of the specific gravity above mentioned. The series in column II. with these solutions diluted with equal measures of distilled water, presenting in an equal length and breadth of liquid, twice the depth. It will be seen that the resistance was very nearly the same.

The solutions of 1·042 specific gravity were then successively placed within the galvanic circuit, and a constant length, breadth and depth of the liquid maintained, and the obstruction they presented to the electric current replaced by windings of German silver wire. The windings correspond to and express the resistance the liquids severally presented.

Table I. presents the results obtained under the following conditions.

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* Pogg. Ann., Bd. lxx, s. 238, and Amer. J. Sci., vol. v, ii ser., 1848, 343.

Specific gravity of liquid, ... 1·042
Cross section of liquid, ... 0·00172 M.
Length of layer, ... 0·4 M.
Strength of battery, 5 Bunsen's pairs.

The exceptions in relation to the results under II. and III. have already been alluded to.

Column A contains the number of experiments; column B, the degrees of deflection of the magnetic needle as indicated by the galvanometer; column C, the windings and decimal fractions of windings of German silver wire, as indicated by Wheatstone's Regulator.

TABLE I.

		BaO, HCl		BaO, HCl		SrO, HCl		SrO, HCl		CaO, HCl		MgO, HCl
		I.		II.		I		II.				
A	B	C	B	C	B	C	B	C	B	C	B	C
1	14°	37·42	14°	36·04	14°	24·07	15°	28·68	16°13′	22·98	16°15′	23·18
2	11	39·60	12	38·10	13	27·91	12	27·04	15	22·90	19	21·87
3	12	35·50	..	....	15	26·62	12	26·78	15 30	22·95	16	22·80
4	13	34·00	..	....	13	26·88	..	....	15 30	23·84	14	23·71
5		....	..	....	12	27·34	..	....	14	21·75	....	22·89
Average,		36·63	..	37·07	..	26·56	..	27·50	....	22·88	....	22·89

The subsequent experiments were made with the platinum diaphragms ·25 M asunder, the specific gravity 1·042 and the remaining conditions the same as in the experiments above recorded.

It will be observed that the resistance is pretty nearly in the ratio of the diminished length of the layer of liquid in the case of the hydrochlorates. The want of precise correspondence was ascribed to the presence of chlorine upon the platinum plates producing the effect of so-called polarization. The odor of chlorine was remarked in the experiments with the hydrochlorates.

TABLE II.

		BaO, HCl		SrO, HCl		CaO, HCl		MgO, HCl
No. of experiment.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.
1	13°	20·36	12°	17·09	16°	15·12	18°	14·90
2	"	20·73	14	17·38	"	15·19	"	14·60
3	"	21·93	14 ·30′	17·36	"	15·15	"	14·92
4	"	20·45	"	17·81	"	14·70	"	14·72
5	"	20·98	14	17·97	"	15·10	"	14·45
6	"	21·75	"	17·89	"	15·30	"	14·49
7	"	20·75	"	17·65	"	14·54	"	14·99
8	"	20·28	"	17·70	"	15·03	"	13·90
9	"	20·04	"	16·93	"		"	14·05
10	"	20·18	"	17·00	"		"	14·14
11	"	20·94	"	17·03	"		"	14·94
12							"	14·38
Average		20·76		17·34		15·01		14·54

TABLE III.

		BaO NO$_5$		SrO, NO$_5$		CaO, NO$_5$		MgO, NO$_5$
No. of experiment.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.
1	14°	31·25	14°	29·31	17°	20·29	16°	17·66
2	"	31·15	"	29·47	16	21·41	"	17·97
3	"	30·25	"	29·26	"	20·47	"	17·90
4	"	31·78	"	28·90	"	21·10	"	17·34
5	"	30·00	"	29·10	15	21·39	"	17·99
6	"	31·20	"	28·76	"	20·81	"	17·72
7	"	30·23	"	28·50	"	20·02	"	17·28
8	"	30·07	"	28·12	"	21·57	"	17·85
9	"	30·37	"	29·22	"	20·45	"	17·01
10	"	30·00	"	28·40	"	20·20	"	17·90
11	"	30·08	"		"	20·10	"	17·21
					"	20·00	"	17·62
					"	20·01	"	17·57
					"	20·15		
					"	20·58		
Average		30·58		28·90		20·57		17·62

TABLE IV.

		*BaO, $\bar{A}$		SrO, $\bar{A}$		CaO, $\bar{A}$		MgO, $\bar{A}$
No. of experiment.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.	Deflection of needle.	Windings of German silver wire.
1	9°·30′	34·48	12°	36·33	12°·30′	36·42	12°	35·26
2	"	34·02	"	36·00	11	36·12	"	34·60
3	"	34·00	12 ·30′	36·97	9 ·30	36·62	"	35·08
4	"	34·50	"	36·00	9	35·00	"	35·29
5	"	34.90	"	36·55	8 ·30	35·31	"	35·69
6	"	34·26	"	37·39	"	35·00	"	35·45
7			"	36·13	"	35·25	"	35·04
8			"	37·25	"	35·39	"	35·09
9			"	36·27	"	35·60		
10			"	37·02				
11			"	37·00				
12			"	36·08				
13			"	36·04				
14			"	37·15				
Average		†42·95		36·50		35·63		35·18

SUMMARY OF RESULTS.

I.

Salts.	Atomic weights.	Results. I.	II.	III.
BaO, HCl, .	152·0	36·63	37·07	20·76
SrO, HCl, .	88·3	26·56	27·50	17·34
CaO, HCl, .	64·5	22·88	. .	15·01
MgO, HCl, .	56·7	22·89	. .	14·54

II.

BaO, NO$_5$, . . .	130·5	30·58
SrO, NO$_5$, . . .	105·8	28·90
CaO, NO$_5$, . . .	82·0	20·57
MgO, NO$_5$, . . .	74·2	17·62

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* Length of liquid section ·20 M.

† ·20 gave 34·36, ·25 would give 42·95.

III.

$BaO, \bar{A}$,	127·5	42·95
$SrO, \bar{A}$,	102·8	36·50
$CaO, \bar{A}$,	79·0	35·63
$MgO, \bar{A}$,	71·2	35·18

The above results led to the conviction that all the attributes of these metallic bases and their compounds would probably be found intense in the order of their atomic weights, a conviction which I expressed after presenting a summary of the foregoing results, to the meeting of the American Association in 1847.

I had then projected the scheme of decomposing the several salts of these bases by transmitting steam over them while subjected to heat. Circumstances prevented my realizing this intention, and in the following year, Mr. Tilghman of Philadelphia, to whom my researches could not have been known, as they had not been published, announced the results of a series of most important experiments—under the head of "Decomposing power of water at high temperatures."*

Mr. Tilghman found that, while a moderate heat was required to decompose sulphate of magnesia with the aid of steam, a higher one was necessary for sulphate of lime, a still higher one for sulphate of strontia, and the highest of all for sulphate of baryta. Thus, their susceptibility to decomposition is in the order of their solubility, viz.—

1. MgO, SO_3
2. CaO, SO_3
3. SrO, SO_3
4. BaO, SO_3

This research fulfilled my expectations, and it would seem that there can be little hazard in considering the above facts as illustrations of a natural law applying to the group of the alkaline earths.

Art. XXI.—*On the American Prime Meridian;* by Professor J. Lovering, of Harvard University.

As extensive circulation has been given in the pages of this valuable Journal and otherwise to the views and arguments of those who advocate the adoption of an American prime meridian, it is incumbent on those who entertain serious objections to this important measure to state them fully and frankly; and, if possible, in season to prevent the consummation of a change which they consider uncalled for by the necessities of science and disastrous to commerce. The remarks which I propose to make, at this time, are substantially the same as were prepared in reply to a printed circular addressed to me; which, as it expresses the history of the measure so far as it has yet proceeded, more felicitously than I can hope to do, I take the liberty of introducing here as the preface to what I have to say.

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* Chem. Gaz., 1848, p. 181.

"Cambridge, Mass., Sept. 17, 1849.

Dear Sir,—At the late meeting of the American Association for the Advancement of Science, held at this place, a Committee was appointed upon the subject of an American Prime Meridian, of which you were elected a member.

This committee had its origin in the following circumstances:—

Having been charged by the Hon. William Ballard Preston, Secretary of the Navy, with the duty of preparing for publication the American Nautical Almanac, provided for by the Act of Congress, approved March 3, 1849, I addressed to him a letter concerning the prime meridian to be adopted in the calculation of this work, the selection and determination of which form the first step in my progress.

Mr. Preston, in his reply (dated August 7) to this communication, directed me "to bring the subject of an 'American Prime Meridian' before the American Association for the Advancement of Science, to convene at Cambridge, Mass., on the 14th instant, for the purpose of soliciting the opinions of the principal mathematicians and astronomers upon that highly interesting subject."

In compliance with these instructions, I submitted to the Association a paper,* the same in substance as my letter to the Hon. Secretary, which, upon motion of Professor A. D. Bache, Superintendent of the U. S. Coast Survey, was referred to a committee, consisting of twenty-two members, (whose names are subjoined,) with instructions 'to send a copy of their Report to the Hon. William Ballard Preston, Secretary of the Navy.'

A meeting of as many of this committee as were then present was held, and a sub-committee, consisting of Lieut. Davis, Prof. Bache, and Lieut. Maury, was appointed to conduct the correspondence, and to execute the instructions of the Association.

The persons composing the whole of this committee are so remote from each other as to preclude the possibility of a general meeting to discuss this question, and agree upon any common report; it has been determined, therefore, as the best means of obtaining their views, to address each member of the committee separately.

Accordingly, I have the honor, as chairman of the sub-committee, to transmit to you a copy of the paper presented to the Association by myself, and also of another paper on the Prime Meridian, by Professor Holton, referred to the committee, and to ask your early attention to this communication.

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* See this Journal, viii, 394, November, 1849.

These papers will serve to suggest the principal topics to which your attention is invited, and will, I hope, lead to a free communication of your views and reflections. It is not impossible that the letters of the committee may be hereafter officially called for; you are requested to state, therefore, whether you object to having your letter printed, and, if no objection is given, I shall feel authorized to make it public, if required.

Very respectfully, Your obedient servant,
Charles Henry Davis,
Lieut. U. S. Navy, Sup't Nautical Almanac.

Prof. Joseph Lovering, University at Cambridge, Cambridge.

List of the Committee on the Prime Meridian.

Prof. A. D. Bache, Sup't U. S. Coast Surv'y.
Lieut. M. F. Maury, Sup't Nat. Observat'y.
Prof. F. A. P. Barnard, Univ. State of Ala.
Prof. Lewis R. Gibbes, Charleston, S. C.
Prof. Edward W. Courtenay, Univ. of Va.
Prof. Stephen Alexander, Princeton Coll.
Prof. John F. Frazer, Univ. of Penn.
Prof. H. J. Anderson, New York.
Prof. O. M. Mitchell, Cincinnati.
Prof. A. D. Stanley, Yale College.
Hon. Wm. Mitchell, Nantucket.
Prof. Joseph Lovering, Cambridge.
Prof. William Smyth, Bowdoin College.
Prof. Joseph Winlock, Shelby Coll., Ky.
Prof. Geo. W. Coakley, St. James's Coll., Ky.
Prof. Curley, Georgetown College.
Prof. J. S. Fowler, Franklin Coll., Tenn.
Prof. James Phillips, Univ. of N. Car.
Prof. Wm. H. C. Bartlett, West Point.
Prof. Ebenezer S. Snell, Amherst Coll.
Prof. Alexis Caswell, Brown University.
Lieut. C. H. Davis, Sup't Nauti'l Almanac."

In reply to this circular, I addressed the following remarks, in substance, to Lieut. C. H. Davis, the chairman of the sub-committee of the Committee of the American Scientific Association on the American prime meridian.

Engagements which could not be postponed have prevented me from giving a more prompt reply to the circular addressed to the committee of the American Scientific Association to whom the subject of the American prime meridian was referred. Having read with interest and attention the papers on this subject communicated to the Association by Lieut. C. H. Davis and Professor Holton, I desire to submit the following remarks.

No other matter presented to the Association at its recent meeting seems to me to compare in practical importance with this. Every one must wish to see the influence of the Association, whose opinion on this subject has been solicited, exerted in the right direction, so as at the same time to promote the interests of science and secure the respect and confidence of the community. It is, therefore, with a feeling of responsibility which I would willingly transfer to those worthier to bear it, that I undertake to offer an opinion upon a subject which involves considerable interests, affects the comfort and safety of a large class of citizens, and perhaps also the honor and prosperity of the country through much of her future history.

The real question I have to consider is whether, after having continued to count our longitudes from Greenwich since we have had a political existence, we shall now abandon that prime meridian and substitute an American one in its place. The Committee of Congress to whom was referred, on the 25th January, 1810, the memorial of William Lambert, recommended that "in order," as they say, "to lay a foundation for the establishment of a first meridian in this western hemisphere," it is expedient to make provision by law for determining the longitude of Washington and procuring the necessary instruments for this purpose. No action appears to have been taken by Congress on this report of the committee. Although the subject for many sessions was pressed upon the two houses and various reports were made upon it, it was not until the 3d March, 1821, that a joint resolution was passed, authorizing the President to employ means for determining the longitude of Washington. The arguments used on the occasion represent the measure as the preparatory step for the establishment of an American prime meridian, passing through Washington. Nothing, however, was done by Congress at that time which committed it on the latter question. After the resolution just referred to had been carried partially into effect, repeated efforts were made, during the administrations of Monroe and of Adams, to prosecute the subject farther and establish a National Observatory, but without success.

The good sense of the people has kept them in the right track thus far. Occasionally, in our school atlases, the longitudes in the United States are counted from Washington. In these cases, we generally find on the opposite side of the map the corresponding longitudes as measured from Greenwich. In more important matters, as the regulation of chronometers, the construction of sea-charts and whatever relates to geography and astronomy as well as to navigation, the custom is universal of counting our longitudes from Greenwich. Lieut. Maury has followed this custom in his charts of winds and currents, and Professor A. D. Bache has done the same in his maps of the coast, although he also gives the longitudes as measured from some one of the American meridians.

In 1810, the late Dr. Bowditch declared the meditated change of the first meridian from Greenwich to Washington to be inexpedient, as well as extremely difficult if not impossible unless the government incurred the expense of founding an Observatory and publishing a Nautical Almanac. Dr. Bowditch did not object to a Nautical Almanac or a National Observatory, but he considered a good survey of the coast more necessary than either. The liberality of the government has provided in turn for all three. Because in 1810 Dr. Bowditch urged, in addition to other arguments against an American prime meridian, its impracticability for want of a National Observatory and an American Nautical Almanac, and because he declared the establishment of such an Almanac and such an Observatory to be the only effectual way of bringing an American meridian into use even by our own countrymen, advantage has been taken of this language to prove that, at the present day, this high authority must be considered in favor of an American prime meridian. Such an inference is based on the presumption that whenever any change becomes practicable it is therefore to be desired; and, in the present case at least, it is wholly unwarrantable. Whoever will consult the papers of Dr. Bowditch on this subject in the ninth and tenth volumes of the Monthly Anthology, will be convinced that the principal force of his argument against an American prime meridian, is just as pertinent in 1850 as it was in 1810. With or without an American Nautical Almanac, Dr. Bowditch condemned an American prime meridian as an innovation which would not be "attended with one real advantage."

In a Nautical Almanac, the principal object of which is to give the places of the sun and moon among the stars and planets, at frequent intervals during the whole day, it becomes necessary to select some spot on the earth as the origin of absolute time and the first meridian for longitudes. The superintendent of the American Nautical Almanac is now called on to make his selection. But the establishment and perfect success of an American Nautical Almanac will in no degree be promoted by the selection of an American first meridian, as the basis of its calculations. Lieut. Davis observes: "Our National Observatory at Washington must have existed half a century before it will be able to furnish independent observations sufficient for the determination of a correct theory of the moon or primary planets. But these theories are already calculated from the observations (begun long since and uninterruptedly continued) at the old established observatories of Europe. In preparing new tables I shall avail myself of the Washington observations to the utmost extent of their utility."

Thus it appears that the materials and whatever is most valuable and indispensable for the calculation of an American Nautical Almanac will be and must be borrowed from Europe for many years. I see no reason why we should scruple to reckon from our old prime meridian, even if it do intersect countries to which we lie under such heavy scientific obligations. Certainly, if the British Nautical Almanac is calculated for Greenwich, the American may be also. If both are based on the same identical observations, it can make no difference, either in the dispatch or accuracy of the work, whether the calculations are made at Greenwich or at Washington. Indeed, I think it will appear hereafter that a Nautical Almanac, wherever calculated, which relies on European observations, can be calculated more accurately for an European prime meridian than for an American meridian.

Let us next consider the chief aim contemplated in the establishment of a Nautical Almanac. There can be no doubt that the British Nautical Almanac, at least, was designed for the benefit of seamen exclusively. Before its foundation in 1767, each navigator calculated the places of those bodies which he used in his reckoning for longitude directly from the tables. Thus he was liable to an error of a degree or about sixty geographical miles, in assigning his position at sea. Then it was proposed that the places of the moon and other useful bodies should be calculated from the tables by able astronomers: that these places, corresponding to short intervals during the day, should be published; and that easy means should be furnished for interpolating the place of any one of them at any moment between the hours for which the places are given. As much as possible of the business of navigating the ship was to be anticipated; and as little as possible was to be left to the navigator himself, to be done by him in the hurry and anxiety of the moment. It was supposed, that calculations made under the most favorable circumstances and tested in manifold ways by expert computers, must vastly transcend in accuracy the best that could be made by the most skilful sailor amid the other duties, vexations and perils incident to his profession. Such I believe to have been the design of Nautical Almanacs, whenever and wherever they have been instituted.

The same considerations dictate that no innovations, such as the change of an established prime meridian, whereby fresh perplexities and dangers may be entailed on a profession already too much exposed to uncertainty in every form, should be made without the most clear exhibition of their necessity. I do not suppose that an American sea-captain, qualified to navigate a ship across the Atlantic, is incapable of understanding the relations of different meridians, and of allowing, whenever he compares his reckoning with that kept on board a British vessel, for any difference which may hereafter exist in the established prime meridians of Great Britain and the United States. I only say that this labor, which might generally be done with accuracy, would occasionally lead to mistakes and ought not to be required of the navigator, unless there is some uncontrollable necessity for it. Otherwise, the very class of men for whose benefit an American Nautical Almanac should be designed, will be the most injured by it. I object, therefore, to any change in the prime meridian to which our navigators are accustomed, on the ground that it furnishes new occasion for error, which no one, however careful and however accomplished, can always avoid, and that it introduces a daily inconvenience into the life of every American navigator, and subjects him daily to one new chance of disaster.

Other countries, we are told, in the development of their resources and their science, have established a prime meridian in their own territories: why should not the United States? The example of the European governments can have little value for us in a nautical point of view. Their commerce on the ocean is comparatively circumscribed; and even did they adopt the prime meridian of Greenwich, they are debarred from a free intercourse with each other and with British and American vessels by a strange language. Besides, in countries where the people, from their habits or their landlocked position, are so much more withdrawn from maritime pursuits than we are, we should expect that their almanacs would consult more the want of astronomers and less the convenience of navigators. There is not one of these countries which is not obliged, as soon as it comes out into the ocean, to defer, to some extent, to the meridian of Greenwich in its use of chronometers and charts; and some, having learned by experience the folly of an assumed independence which worked for them real mischief, have already begun to retrace their steps back to Greenwich.

But our own experience and judgment are worth more than the example of any foreign nations. We speak the same language as the British navigator: why should we be at pains to learn a different scientific dialect? Why should we endeavor to forego all the innumerable advantages we derive from our common origin, and discard an existing agreement in regard to scientific standards which other nations have striven so long and hopelessly to consummate? The communication of Lieut. Davis does ample justice to the importance of an universal prime meridian. There is no reason to believe that a single first meridian can ever be established by the common consent of nations. All desire it, but how many will agree upon the choice? Let us not, in the pursuit of this chimera, adopt the temporary expedient of an American prime meridian, and thus renounce an inheritance to which we were born; throw the whole of this great good to the winds: and postpone, as we must for centuries, the realization of the grand desire of all hearts for a universal meridian. So long as America and Great Britain continue to use a single prime meridian, they alone can make that meridian, for all important nautical purposes, a universal prime meridian, and we at least shall enjoy, not in prospect but in immediate fruition, all the substantial advantages of such a meridian.

The foregoing remarks are designed to show that the adoption of an American prime meridian will violate the spirit in which other governments have established Nautical Almanacs, and will entail upon the commerce of the country, for several generations if not forever, an amount of daily inconvenience and danger which, in the aggregate, cannot be overestimated.

I now propose to consider the reasons that are urged in favor of an American prime meridian. The only reason of a scientific character which has been given for the proposed change is founded upon the slight error which still affects the best determined American longitudes as reckoned from Greenwich, arising from our ignorance of the exact breadth of the Atlantic ocean. Assuming the uncertainty which still exists in the corrected longitude of Boston to amount to two seconds of time, as stated by Lieut. Davis, this is equivalent to an error of about half a mile in longitude. Half a mile, under the circumstances, is a large error for the astronomer; but to the navigator, who will compare it with other errors to which he is exposed, it will appear quite insignificant. The best chronometers, transported in the British steamers between Liverpool and Boston, are liable to vary four seconds. The errors incidental to the lunar method of calculating a ship's longitude, originating either in errors of the tables or errors of observation, are sufficient to produce an uncertainty, to the amount of ten miles at least, in regard to the position of a ship. The lingering error of half a mile, which still disturbs the longitudes of those American ports whose distance from the continent of Europe is most accurately measured, is small when compared with the fluctuations of chronometers or the doubts which beset the ordinary methods of fixing a ship's position at sea. Whether the error is large or small, important or unimportant, the proposed change of the prime meridian from Greenwich to some spot in America will not contribute in the least to release the navigator from the effects of it. I will suppose a ship which counts its longitude from Greenwich to leave Boston, with its chronometers set at Boston to Greenwich time. These chronometers may differ from true Greenwich time by two seconds, and there may exist an uncertainty to that amount, on arriving upon the European coast, in regard to the precise position of the ship. But when the same ship returns, its chronometers may be set to true Greenwich time. Still the homeward voyage of the navigator will be no surer nor safer than his outward voyage. For, though his chronometers may be correct, he knows not within half a mile the longitude of the port for which his ship is destined. Suppose, the same ship to start again upon another voyage with its chronometers arranged to an American prime meridian. The same difficulties will reappear, though in an inverted order. The captain leaves home with his chronometers set to true American time, but he cannot tell within two seconds the longitude of his European port, and on this account, when he is homeward bound, his chronometers must be stamped by the same error of two seconds. In other words, if we do not know the exact distance from Liverpool to Boston, neither do we know any better the distance from Boston to Liverpool. If the longitudes of American ports as counted from Greenwich cannot be accurately given, neither can the longitudes of any foreign port as counted from an American prime meridian. The importation of a prime meridian from Europe to our own territories will not, I conclude, operate for the improvement of our navigation.

Neither do I believe that our knowledge of American geography will be advanced by an American prime meridian. The longitudes of a large number of places in the United States have already been determined with great accuracy by the usual astronomical methods or by the transportation of chronometers; and the relative differences of longitude between the principal spots on our coast and those cities and observatories whose longitudes are best known will be assigned through the operations conducted by the excellent superintendent of the U. States Coast Survey. Were all our longitudes to be calculated from observations of eclipses, occultations or transits, so rapidly is the number of observatories and observers increasing over the whole country, there is reason to believe that the capital places in all the states and territories would be determined in this way, if not with absolute precision, with all the accuracy that is wanted for the construction of a correct geographical map of the United States. In this case, however, not only might the absolute distances from Greenwich slightly fluctuate, but the relative distances from each other also. For we could hardly expect that the longitudes of all these places, as measured independently from Greenwich, would be determined with equal precision. We should rather suppose that the meridians most remote from Greenwich and less crowded by population would not, in general, be projected so carefully as the nearer and older meridians. But the transportation of chronometers from place to place will give our relative longitudes independently of any uncertainty as to the exact distance between the eastern and western continents. Thus not only will the relative longitudes be known as accurately as they could be with an American prime meridian, but the absolute longitudes of each and all from Greenwich will be known as accurately as the best; so that, hereafter, though the absolute numbers might change by infinitesimal quantities, the relative numbers will be permanent and our map will be permanent. Moreover, the superintendent of the U. States coast survey has applied with triumphant success the admirable telegraph of Professor Morse to the determination of the longitudes of places intersected by the telegraphic wires. The country is already traversed, in every direction, by the grand telegraphic lines, and these will be crossed in a few years, at a multitude of points, by a finer network. If we wait this short time, our relative longitudes will be ascertained with a precision, a simplicity and an economy wholly unprecedented as yet in the scientific history of any country in the world; and without any reference to our first meridian, whatever it may be. The map and the meridians upon it will never fluctuate. The floating error to the extent of half a mile in regard to the exact distance between Greenwich and Washington, or any other spot in America, this error or uncertainty in regard to the breadth of the Atlantic ocean on which so much stress is laid, can produce no more derangement in a map of the whole or any part of the United States, than when we push a map from one side to the other of our table. If we desire to unite a map of the United States with a map of Europe so as to form a map of the world, then the uncertainty in question will manifest itself. But no alteration in our prime meridian from one place to another will remove or diminish it; it is absolutely insurmountable. After we have made our map of the United States and drawn the meridians upon it, the selection of numbers to describe these meridians is a question of convenience rather than of scientific accuracy. If we count these meridians from Greenwich, the difference of two numbers will give the relative difference of longitude between the two meridians to which they are affixed. These differences will be permanent, though the absolute numbers may change by some constant quantity, and the differences as well as the absolute numbers may be placed upon our maps and charts if the convenience of those who use them requires it.

I am not able to see that any other scientific operations will be materially affected by the substitution of an American prime meridian for that of Greenwich. I do not see that the details of the American Nautical Almanac or the calculations of those who use it, whether astronomers, navigators or engineers, will be ensured any greater accuracy by the establishment of an American prime meridian. The uncertainty to the amount of two seconds of time in relation to the distance which separates American from European meridians must vitiate, and, as I believe, to the same extent, all our calculations for practical and scientific purposes, until either the uncertainty itself is removed, or we are prepared to make American science in spirit as well as in form, wholly independent of those precious results which centuries of labor have garnered up at the venerable observatories of Europe. If we use an astronomical ephemeris, calculated in Europe for an European prime meridian, or calculated in our own American almanac from European observations and for an European prime meridian, the uncertainty of which I speak, though it does not affect the ephemeris itself, will affect the application of it to our own meridians. On the other hand, if we undertake to calculate an ephemeris for an American first meridian, this ephemeris, though it may be as good when applied to one American meridian as another, will be inaccurate for all, because it has been calculated from European observations. An astronomical ephemeris, calculated exclusively from a long series of American observations would, I doubt not, be better adapted to the wants of American astronomers and serve more effectually the purposes of

American science than any arrangement which can be made under existing circumstances. No one looks more confidently to the future to realize this maturity of American astronomy than I do; and no one, certainly, will more gladly hail it when it shall have arrived. Long before the advent of that happy day, the principal difficulty which American astronomers now experience will have vanished of itself. For it cannot be that the costly and elaborate operations which the government are now conducting under the supervision of the superintendent of the coast survey, with the object of ascertaining with greater nicety the difference of longitude between Cambridge, U. S. and Greenwich, will be of no avail.

I am aware that an American prime meridian would be of some convenience to the single observatory through which it might pass. It is possible that an ephemeris, calculated for that observatory, could be corrected for other observatories on neighboring meridians with a little more dispatch than an ephemeris calculated for so distant a meridian as that of Greenwich. I presume, however, that a little more time and care will ensure as much accuracy in the latter case as in the former. At any rate, if it should appear that the astronomers of the country and others whose pursuits, scientific or practical, require them to handle such an ephemeris, would be essentially accommodated by one which is calculated for an American first meridian, or if it should appear that, in the opinion of those who have charge of our principal observatories or are otherwise most competent to judge, the interests of astronomical science would be materially advanced by such an ephemeris, it may deserve consideration whether one ought not to be provided for their peculiar benefit and that of the science which they cultivate. But, in our desire to promote the science of astronomy, let us not lose sight of the grand aim contemplated in every nautical almanac; but let us make that in fact what it professes to be in name, *a manual for the advantage and security of seamen.*

In conclusion, I must deprecate any attempt to bring about a change in the first meridian used in this country, by a misplaced appeal to our national pride. This is a question, partly of science, but much more of common prudence; into which, if national honor enter at all, it can only be to forbid the contemplated change. Politically, we are independent of all other nations. But in science, literature, and the arts, we must look to the old world for the most perfect models, and long continue to draw from its rich storehouse much that we prize most highly, in thought and action. We are dependent on the old world, and England particularly, as the child is dependent upon the parent, as each generation is dependent upon those which have preceded it and have contributed to its own greatness and glory. No ingratitude or denial on our part will relieve us from this dependence. By the encouragement which we give to the cultivation of true science in this land, and by the bright example which we hold up to the world of a just as well as a free government, we may hope to pay back a part of the great obligation under which we stand to the older nations of the world and the time-hallowed institutions of Europe.

An American prime meridian will make American science independent in name only, and such an independence can deceive no one but ourselves. Certainly, we shall not be so blind as to be deceived by it. Every thing around us must remind us of our relations with the old world. Our ships are furnished with the chronometers and sextants of Great Britain and France. Our observatories are adorned with masterpieces of art imported from Munich. Our libraries are luminous with the great works of Leibnitz and Newton, Galileo and Laplace. We must wait half a century before we shall have created a fund of observations at our own observatories which will make us independent of similar institutions abroad. How much longer must we wait before we shall have American observations made by American instruments? This is a real dependence. Let us not be humiliated by it, but rather let us take courage from it to imitate, in due season, the honorable achievements in science of the older nations of the world.

But the use of a foreign meridian involves no dependence whatever. We do not hesitate to reckon our latitudes from the equator, though this great circle does not, at present, lie within our own territories. Why should we refuse to count our longitudes from the meridian of Greenwich, even if it be a line intersecting some foreign country? We borrow nothing from Great Britain or any other country when we count our longitudes from Greenwich. It belongs to us and to whoever chooses to use it for this purpose, as much as to them. It belongs to us as much as the English language belongs to us and whatever else that is valuable which we have inherited from our parent of the old world. It belongs to us, for all scientific purposes, as much as the earth's magnetism or the sun's light and heat; as much as the moon, planets and stars; as much as the common atmosphere which warms and feeds us all. There is no property in any of these things. They are the common property of all who think, all over the world; and he most possesses who most uses them.

Should Great Britain and America ever agree to adopt an American prime meridian, it would be a misfortune to us. Should the nations ever agree upon a universal first meridian, the prayer of these United States ought to be that it might not pass across this western continent. Of all nations in the world, we can least afford to sacrifice our coasters to the perpetual annoyance they must experience in crossing it. The meridian of New Orleans, which is recommended by Lieut. Davis as the first meridian of this country, will only furnish a partial remedy for this inconvenience, especially when we consider the new channels opened to our commerce by our enlarged sea-coast on the Pacific. The old maritime nations of the world shifted their first meridian farther and farther westward as their geography and navigation enlarged, that all their commerce might be conducted on one side of it. In this respect also, the meridian of Great Britain is better adapted to the wants of this country than an American prime meridian.

But we cannot expect that Great Britain or any other foreign nation will adopt the American prime meridian. Indeed, it is to be feared that American navigators will not adopt it. They will prefer the British Almanac, calculated for the meridian of Greenwich, to an American Almanac calculated for any other meridian. History declares how difficult it is to effect a revolution in the daily habits of a large class in the community, even where the change is confessedly an advantage to those who adopt it. The change of the prime meridian from Greenwich to America promises no good to any class in the community; it certainly will be attended by great sacrifices and can contribute nothing to our honor or our independence.

The following memorial to Congress, has obtained a large number of signatures in Boston and other seaports of the United States, and been transmitted to Washington.

"The subscribers, merchants, underwriters, and shipmasters of Boston and its vicinity, understanding that a communication has been made by Lieut. Charles H. Davis, of the United States Navy, now charged with the preparation of an American Nautical Almanac, in which it is proposed to change the reckoning of the longitude from the meridian of Greenwich to some place within the United States, beg leave respectfully to submit to you our opinion of this proposed change, and its probable effects upon the navigation of the country.

"The advantages that would result to all commercial nations from marking their longitude from one common prime meridian are too obvious, and have been too often stated, to require any new recital. The evils, however, which might be supposed to result from the great diversity of prime meridians have been of no considerable practical importance to the United States: our navigators have hitherto computed from Greenwich, which, being thus common to them and Great Britain, forms the basis of the longitude of four-fifths of the commerce of the world. This meridian of the English tongue, as it may be called, which is fixed upon all the maps, charts, and books known to our service, it is now proposed to change. We are not possessed, in our own knowledge, of a single good reason for this change; nor can we find any such in the elaborate and ably-drawn argument of Lieut.

Davis. In no single case will the labor of the navigator be abridged, or his knowledge of his place upon the ocean rendered more certain; but, on the contrary, the confusion, incident to the introduction of a new meridian into his books, his charts, and his memory, will be attended with constant perplexity, miscalculation, and mistake, which must cause a serious increase in the hazard of all the lives and property under the American flag.

"Permit us to specify a few of the evils thus predicted:—*1st*, We shall have introduced upon our own coast the east and west reckoning; and although, by making the first meridian at New Orleans, most of the coasting trade will be upon one side of the meridian, yet all vessels passing to the coast of Texas must change their longitude from east to west, and be subject to all the perplexities of that change. *2nd*, It is now the common practice for navigators at sea to communicate to each other their longitude. This practice is exceedingly useful, and has often led to the correction of errors which must otherwise have been fatal. But this is done in the haste of passing, often in storms and partial darkness,—conditions very unfavorable to hearing and understanding with accuracy even the simple numbers that express the degrees and minutes of longitude. But, if the proposed change of meridian is adopted, another element must be introduced in all communications between English and American vessels, and for a long time between American vessels with each other; and the failure to give the reckoning as from Greenwich or New Orleans, or to hear and understand it rightly when given, may involve ship, cargo, and navigators in one common ruin. *3d*, A portion of the charts used by United States navigators are, and must continue to be for an indefinite period, of English construction, and consequently marked with the longitude of Greenwich. To reduce this to the American standard upon a sudden emergency, and when perhaps surrounded by danger, cannot be effected, however simple the operation, by all persons, without occasional error; and it must be remembered, that, in these cases, life and death may hang upon the error of a single mile. Some of these evils may be of a temporary nature, which will pass away in a few generations, with the loss of a limited amount of life and property: others, however, must remain, even after the universal adoption of the new reckoning by all the navigators of the United States, and the substitution of books and charts, for all parts of the world, adapted to the new meridian.

"Against all this perplexity and mischief, which must attend the proposed change, its advocates have not *pointed out a single countervailing practical advantage;* but it is suffered to rest, by Lieut. Davis, upon a *supposed* scientific necessity, and upon considerations in some way connected with our national independence.

"Waiving all observations upon the assumed scientific necessity, save the single one that we are unable to perceive that it is affected in the least degree by the proposed change, we beg leave to add a few words regarding an American meridian, as connected with our national honor or independence. Did we believe it true that the honor or independence of the United States were in the least degree affected by counting our longitude from a meridian line passing through an English Observatory, we would readily encounter all the evils of a change; but we do not believe that any such taint rests upon this practice. We received this mode of counting our longitude, as we received our language, our arts, our names, our very blood, from England, our parent state. The meridian of Greenwich belongs to us, in common with the English nation, by right of inheritance from our fathers, who helped to rear and support the observatory first established there. Our property in this is more clear than in the compass, the chronometer, and many other instruments of navigation; and the same principle of an ideal independence, which shall require us to abandon the meridian of Greenwich, must require us to abandon most of our instruments of art, science, literature, and even our language, for we hold them all by the same tenure; and the question will come to be, not what we shall resign, but what we shall have left. Permit us further to observe, that this state of ideal independence, in marking the longitude, will not be at all attained by the change proposed. It is intended by Lieut. Davis to make the prime meridian *completely dependent upon Greenwich.* It is not to be the meridian of any point arbitrarily assumed at New Orleans, but a line as near as possible to 90 degrees west of Greenwich, which, by a coincidence purely accidental, passes through or near New Orleans. Indeed, the necessities for a continued dependence upon foreign observatories for observations for half a century is distinctly avowed. Without this foreign aid, the proposed almanac could not be prepared. The change, then, will be merely nominal. We shall not reckon our longitude really from New Orleans, but from a point 90 degrees west of Greenwich; and the longitude of Washington, for example, will not be so completely described by saying that it is 12 degrees 56 minutes east of New Orleans, as by calling it 12 degrees 56 minutes east of a meridian 90 degrees west of Greenwich.

"In conclusion, and after a review of the whole subject, we can perceive no reason for abandoning the meridian of Greenwich, or any other of the common property of civilization. If the use of the instruments of art or the methods of science, introduced by other nations, be beneficial to us, the most high-minded and truly independent and national spirit would seem to dictate, not that our practice and usages should be changed, but that we should, by the cultivation and advancement of branches of knowledge, where our efforts can be useful, repay to mankind the advantages which we have received from the common stock of civilization."

ART. XXII.—*On Perfect Musical Intonation, and the fundamental Laws of Music on which it depends; with remarks showing the practicability of attaining this Perfect Intonation in the Organ*; by HENRY WARD POOLE, Worcester, Massachusetts.

(Concluded from page 83.)*

28. THE opinion has been very generally entertained among musicians, that there is a peculiar character belonging to each of the keys. We should not have considered this opinion worthy of notice in this connection, but for the reason that many have attributed this real, or supposed, peculiar character to temperament; for if this peculiarity exists in nature, and is inherent in music itself, it will be especially manifest in a system, or on an instrument, of Perfect Intonation. If, however, temperament is the source of a *variety* which is so highly appreciated by some, it is certainly an argument in favor of temperament, and against Perfect Intonation.

29. We have before us a musical work, of no small reputation, from which we copy the characters, or "complexions," of several of the keys. "C, Bold, vigorous, commanding. D, Ample, grand, noble. D♭, Awfully dark (!) E, Bright, pellucid, feminine. F, Rich, mild, sober. G, Gay and sprightly. A, Golden, warm, sunny. A♭, The most lovely of the tribe; unassuming, gentle, soft, delicate and tender, having none of the pertness of A in sharps. B, (in sharps) keen and piercing. B♭, the least interesting of any, &c., &c." These ideas have been formed and perpetuated by a sort of musical creed, and is said to have for its authority, "the common consent of musicians." It is not so much our purpose to oppose this beautiful theory, as to show, that no argument can be drawn from it to sustain temperament. If temperament be assigned as the cause why the key of A differs in character from the key of A♭, the difference must be found in the fact that one is tempered differently from the other. If tempera-

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* In our article in the last No. of the Journal, we gave a brief account, so far as we were informed, of all the attempts that have been made to attain *Perfect Intonation*. Since the January No. was issued, our attention has been called, with no little surprise, to a recent No. of the Westminster Review, vol. 50, page 253, Am. ed., in which an allusion is made to an improvement in the organ, similar to ours, which has recently been brought out in London, by Col. P. Thompson. Of the details of Col. Thompson's invention we know nothing, as our knowledge is entirely confined to the notice referred to, and there it is alluded to, simply to illustrate some truths, of which we are now endeavoring to convince the American public. It might have appeared remarkable that the same invention should have been made at the same time, after the subject had been reposing so quietly for forty years—the parties being so remote and knowing nothing of what the other was doing—if the history of science did not furnish even more remarkable instances of the kind. If the invention in England is as successful as ours, it will illustrate this simple truth, that, in the course of human events, the time for *Perfect Intonation* has arrived.

ment was adjusted in any uniform manner, through the different classes of instruments, and by different tuners, there would be a show of argument, in the fact, for temperament. But we find no such uniformity; different instruments are tempered in a widely different manner; and on one instrument the key of A is tempered like the key of A♭ on another. If an instrument be tuned in the *equal temperament*—which is the more common and popular—every key is tempered *precisely alike*, and consequently all peculiarity from the cause assigned will disappear. If an alteration of *pitch*, either, be the cause, as some have supposed, of this peculiarity in the different keys, as instruments often vary from one another, in pitch, a semitone, it will often be difficult to decide which is the "soft and tender" key of A♭, and the "pert" key of A. If an organ be tuned correctly in the key of A♭, (or four flats,) and the temperature of the room rise a few degrees, the relative pitch of the whole organ will rise a comma, and the music played in the key of *four flats* will have the *character* (if this theory be correct) of the key of *eight sharps!**

30. Undoubtedly, in perfect intonation, a certain key is frequently more appropriate for a given composition than any other key; but that a certain key gives to music performed in it, any such peculiarity as we have quoted, is (in our opinion) as fanciful as to suppose that the size of the canvas determines the character of the painting. We will suppose a composer has an idea which he would express in a soft and gentle air; thinking that the character of A♭, renders it the most appropriate key for the expression of his idea, he writes his music in that key and arranges it for a quartette. He executes the music, thus arranged, on his piano-forte, and the soft and gentle effect desired is produced. He then gives it to a quartette to perform, without any accompaniment. They take their pitch a semitone higher than his A♭, that is, exactly in his "pert" key of A. Would the composer

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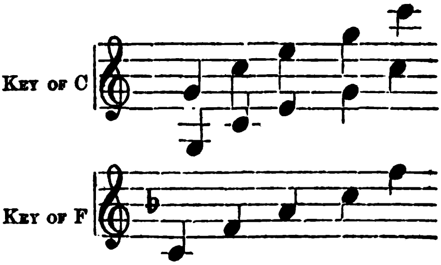
* There is something so very imaginative in this theory of the different keys having different characters, that one might reasonably doubt whether such a theory had any supporters. Such however, we are compelled to say is the fact—it is found in the books, and is taught at the present day, by many teachers of reputation. If any one still doubts the fact, we would refer him to a recent number of the London Quarterly Review, vol. 83, p. 274, Am. ed., where, in an elegantly written article on "Music," the characters and complexions of the several keys afford the writer a theme for many sublime remarks, as if the theory had never been questioned. "A whole Bridgewater treatise" this writer says, "might have been not unworthily devoted to the wonderful varieties of keys alone. He [the composer] knows whether he requires the character of triumphant praise given by two sharps, as in the Hallelujah Chorus of Handel, or the Sanctus and Hosanna of Mozart's Requiem; or the wild demoniac defiance (!) of C minor, as in the allegro of the Freischütz overture; or the enthusiastic gladness of four sharps, as in the song of *Di Piacer;* or the heart-chilling horror (!) of G minor, as in Schubert's Erl King, and all the Erl kings that we have known." A very proper reply to this writer in the Quarterly, can be found in an article on "Greek and Modern Notation of Music," in the volume of the Westminster, to which we have already referred in a previous note.

himself perceive any difference in the effect of his music? We think not; and say moreover, with confidence, that no one, in listening to an instrument, to the pitch of which he is not accustomed, can, with any degree of certainty, decide in what key the music is played. A flute-player may judge correctly as to the key, when listening to an air performed on his own flute—perhaps a flute to which he is not accustomed—for different tones on the flute have different qualities; the high E, for instance, has a different quality from the E♭; but this is admitted to be an imperfection in that instrument, which art has endeavored to obviate. The character of music depends on other things than the *key* in which it is written. Many "soft and tender" compositions have been written in A♭, and many of an opposite character.

One key is more appropriate for a composition than another, for the reason that there will be employed in that key, a range of sounds which are best adapted to the quality and compass of the voices, or instruments, for which the music was composed. Thus if a melody of this compass, (an octave and a fifth,) were written for a soprano or tenor voice, it would not probably be placed in the key of C, as in that key the highest notes would be too high, and the lowest notes too low for convenient execution. Such a melody would more appropriately be placed in a key in the vicinity of F. Assuming F to be the *best* key for it, we believe that the nearer the key is brought to F, the better will be its effect; that is, the key of D will be better than C, E♭ than D, and E better than E♭. Melodies of small compass may be adapted to several keys. In different collections of music before us, the Hundredth Psalm—whose melody is contained in the compass of an octave—is written in four different keys, viz., F, G, A♭ and A.



31. It is necessary to examine more particularly than we have yet done in this paper, the subject of TEMPERAMENT, if we would fully understand how far the scale of the common organ, with twelve notes in the octave, when arranged in the best possible manner, falls short of fulfilling the requirements of music. As we shall have frequent occasion to refer to a table we gave in the January No. of the Journal, (25.) we reinsert that table, (see next page,) for the convenience of those who may not have that No. at hand. It was shown in (11.) that *four prime intervals* are employed in music, viz., the *octave*, *fifth*, *major third* and *perfect seventh*. It

appears from the table that notes which vary by smaller intervals than a semitone, result from combining these four prime chords. In temperament, these four chords are disposed of in the following manner. The *octave* is tuned perfect. For the *perfect seventh*, no provision is made, and it is rejected altogether. The *thirds* and *fifths* remain, to which alone temperament is applied.

Signatures.	Key Notes.	Major Seconds.	Major Thirds.	Dominant Sevenths.	Perfect Fourths.	Perfect Fifths.	Leading notes, Minor scales.	Major Sixths.	Perfect Sevenths.	Major Sev-enths.	Octaves.
5 Sharps.	B^3	C♯^{3}	D♯^{2}	E^7	E^3	F♯^{3}	F+^{1}	G♯^{2}	A^7	A♯^{2}	B^3
4 Sharps.	E^3	F♯^{3}	G♯^{2}	A^7	A^3	B^3	B♯^{1}	C♯^{2}	D^7	D♯^{2}	E^3
3 Sharps.	A^3	B^3	C♯^{2}	D^7	D^2	E^3	E♯^{1}	F♯^{2}	G^7	G♯^{2}	A^3
2 Sharps.	D^2	E^3	F♯^{2}	G^7	G^2	A^3	A♯^{1}	B^2	C^7	C♯^{2}	D^2
1 Sharp.	G^2	A^3	B^2	C^7	C^2	D^2	D♯^{1}	E^2	F^7	F♯^{2}	G^2
Natural.	C^2	D^2	E^2	F^7	F^2	G^2	G♯^{1}	A^2	B♭^{7}	B^2	C^2
1 Flat.	F^2	G^2	A^2	B♭^{7}	B♭^{2}	C^2	C♯^{1}	D^1	E♭^{7}	E^2	F^2
2 Flats.	B♭^{2}	C^2	D^1	E♭^{7}	E♭^{2}	F^2	F♯^{1}	G^1	A♭^{7}	A^2	B♭^{2}
3 Flats.	E♭^{2}	F^2	G^1	A♭^{7}	A♭^{2}	B♭^{2}	B^1	C^1	D♭^{7}	D^1	E♭^{2}
4 Flats.	A♭^{2}	B♭^{2}	C^1	D♭^{7}	D♭^{2}	E♭^{2}	E^1	F^1	G♭^{7}	G^1	A♭^{2}
5 Flats.	D♭^{2}	E♭^{2}	F^1	G♭^{7}	G♭^{2}	A♭^{2}	A^1	B♭^{1}	C♭^{7}	C^1	D♭^{2}

The principle on which it is applied will be seen by the following example. In the table there appear two E's, one obtained by turning a major third from C^2, viz., E^2, and the other, E^3, a comma higher than the first, obtained by tuning a series of *fifths* from the same C^2. It is proposed in temperament to use *one* E for these *two*. It is evident that if E be tuned truly as a major third it will be a comma too flat, in a series of fifths; and also, if it be tuned truly in a series of fifths, it will be a comma too sharp, as a major third. As the error of a comma is *intolerable*,* if occurring in one place, it is usually divided among the four fifths, and the major third. By flatting the fifths, the third is prevented from being so sharp, as it would otherwise be; and sharping the third, will, in like manner, benefit the fifths. Temperament, therefore, is a compromise between the thirds and the fifths, in which each gives up more or less of its purity, in order to favor the other series of intervals.

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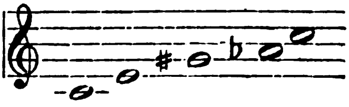
* In correcting opinions on this subject, which, we think, are erroneous, we have already, and shall again refer to Prof. Peirce's treatise "on Sound;" not because the views, to which we take exception, are peculiar to, or original with him. They are also found in other works of the kind of high authority. We have referred to Prof. Peirce's treatise because it is more common, and the learned Professor is at hand to correct us if we err. In treating *Temperament*, in § 108, he says, "The principle on which the reduction of notes is made, is, that if the notes differ from each other by only one vibration in eighty, [or a comma,] the ear can hardly perceive the difference between them, and the substitution of one of them for the other. will not be fatal to harmony." This is another point which the *ear* must decide, and we must set against the Professor's authority not only our own, but the experience of every tuner. Instead of the error of a *comma* being an interval so small that "the ear can scarcely perceive the difference," *a twelfth of a comma* can be, and is, perceived by every intelligent tuner, as this is the interval by which he leaves the fifth flat, in the equal temperament. But a fifth a *whole comma* flat, or sharp, is probably as *discordant*, and "fatal to harmony" as any possible interval.

32. Although temperament may be adjusted in many different ways, yet every possible adjustment can be classified under one, or both, of two general systems, called the MEAN-TONE SYSTEM and EQUAL TEMPERAMENT. The first aims to preserve the perfection of the thirds; while the latter sacrifices the thirds, and gives preference to the fifths.

33. The first is called the MEAN-TONE SYSTEM, for the reason that, instead of preserving the distinction between the major tone of *nine commas*, and minor tone of *eight commas*, it averages the two, and makes a MEAN-TONE, of *eight and a half* commas. Consequently the sum of two *mean-tones* equals the sum of a major and minor tone, or a perfect major third. In tuning the E in this temperament, it is tuned a perfect major third from C, or E^2, as we express it, in the table. This E not being high enough, by a comma, for the E in the series of fifths, the error is divided equally among the four fifths, viz., C to G, G to D, D to A, and A to E, and each is left flat by a *quarter of a comma.* The tuning is continued until *eight* notes have perfect major thirds, and fifths that are a quarter of a comma flat. These are all the chords that can be used in an instrument of *twelve* notes in the octave. In this system, a *sharp* cannot be used as a *flat*, as it will be false by the *enharmonic dïësis*, or about two commas. This is the interval by which three major thirds fall short of the octave, and it is obtained in this manner. Commencing with C, we tune E, a perfect major third, from this E, tune G♯, a major third; and from C, an octave above the first, tune downward a major third to A♭. This A♭ is not as low as G♯, by the *dïësis*, and G♯ will not answer at all for A♭. When common organs, which have but one sound for G♯ and A♭, are tempered on this system, one of these notes, usually A♭, is left so false that it cannot be used. Some organs have an A♭ supplied by a different pipe. The Temple organ, in London, has two notes thus supplied, A♭ and D♯, by the aid of which, that instrument is enabled to play in two scales more than those, tuned in this temperament, which have but twelve sounds in the octave. The mean-tone system bears, in many respects, more resemblance than any other temperament, to the perfect scale. It recognizes a distinction between sharps and flats, diatonic and chromatic semitones, has perfect major thirds, and has its minor thirds nearer to perfection, than in any



other temperament. With these advantages, however, it is justly censured for its discordant fifths, and its "wolfishness" when the modulation is carried into keys, where it is not prepared to play.

34. The EQUAL TEMPERAMENT preserves the fifths nearer to perfection than the mean-tone system, and consequently throws the discord, or "wolf," (as it is termed by tuners,) into the thirds. The fifths, however, although they are favored, are yet not given in perfect tune. It is found in perfect tuning, that a series of twelve fifths will end a comma* higher than the note commenced with. In equal temperament, it is designed to make the series meet, and consequently this comma is equally divided among the twelve fifths, leaving each a *twelfth of a comma* flat. If this be accurately done, the octave will be divided into twelve equal parts, and one fifth will be equally as good (or bad) as another. To set this temperament, it is only necessary to temper the fifths carefully, as has been stated, without regarding the thirds at all. The major thirds will be found sharp, by an interval eight times as large as the error in the fifths, that is, *two thirds* of a comma. The minor thirds will be flat *three fourths* of a comma, or the sum of the temperament of the fifth and the major third. As it is designed, in the equal temperament, to have every chord of the same name, equally tempered, the necessity of leaving the thirds in this condition will be further made obvious. The third part of the octave must be used as a major third, and as three *perfect* major thirds do not equal the octave by the *diësis*, each third must be sharped, by one third of the *diësis*, or *two thirds* of a comma. Again, the minor thirds must be each, one fourth of an octave; but four *perfect* minor thirds overrun the octave by *three* commas; this excess therefore is equally divided among the four minor thirds, and each is left flat, by *three fourths* of a comma.

35. The Equal Temperament has this great advantage over all others—its twelve keys can all be used, they are all tempered alike. The ear, too, is better satisfied when all the chords are *equally out of tune*, than when it listens to constant transition from a better to a worse chord. It can also be demonstrated that in equal temperament, the *sum* of the temperament of all the chords—if the instrument be used in the twelve keys—will be less than in any other. Any other than the equal system, is simply an attempt to improve part of the thirds, by sacrificing, not only the fifths, but the remaining thirds.

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* This comma, which is called the *Pythagorean comma*, results from combining the octave and fifth, which are derived from the primes 2 and 3; and consequently cannot be mathematically the same as the *comma* before mentioned, resulting from the fifths and thirds, or the primes 3 and 5. The ratio of the last, as before stated, is 80:81; the ratio of the *Pythagorean comma* is 524288:531441 or 80:81,091463091068+. It will be seen that the two commas are very nearly the same, and to consider them the same, will greatly simplify the subject of temperament, while it will not involve any material error.

36. The following table will exhibit the temperament of the principal chords and intervals in the two systems.

	EQUAL TEMPERAMENT.	MEAN-TONE SYSTEM.
Fifths,	$\frac{1}{12}$ of comma Flat.	$\frac{1}{4}$ of comma Flat.
Fourths,	$\frac{1}{12}$ " " Sharp.	$\frac{1}{4}$ " " Sharp.
Major Thirds,	$\frac{2}{3}$ " " Sharp	Perfect.
Minor Sixths,	$\frac{2}{3}$ " " Flat.	Perfect.
Minor Thirds,	$\frac{3}{4}$ " " Flat.	$\frac{1}{4}$ of comma Flat.
Major Sixths,	$\frac{3}{4}$ " " Sharp.	$\frac{1}{4}$ " " Sharp.
Perfect Sevenths,	$1\frac{5}{12}$ " " Sharp.	$1\frac{3}{4}$ " " Sharp.
Major tones and Ninths,	$\frac{1}{6}$ " " Flat.	$\frac{1}{2}$ " " Flat.
Minor Tones,	$\frac{5}{6}$ " " Sharp.	$\frac{1}{2}$ " " Sharp.
Diatonic Semitones,	$\frac{7}{12}$ " " Flat.	$\frac{1}{4}$ " " Sharp.
Chromatic Semitones,	$\frac{5}{12}$ " " Sharp.	$1\frac{1}{4}$ " " Flat.
Grave chro. Semitones,	$1\frac{5}{12}$ " " Sharp.	$\frac{1}{4}$ " " Flat.

37. If we extend the science of music and musical ratios beyond the limits referred to in (8.) the errors from temperament, in the mean-tone system, will be increased by the addition of the diesis. As no provision is made in either system of temperament for the chords of "perfect sevenths," it will be seen from the table that they will be extremely harsh, being false by about a comma and a half. These two systems embrace every advantage that can be found in any, and every intelligent tuner knows that no mixed system embraces advantages beyond either of the original temperaments. It is the quack and pretender only, who professes to unite in one system the advantages of both; in other words, to favor the fifths, as they are in the *equal*, and the thirds, as they are in the *mean-tone* system. It is certain that no new system of tempering twelve sounds, so that they will perform correctly the office of several times that number, has been discovered during the last century, and we think we have shown that such a system never will be discovered, while the laws of nature and the mathematics continue the same.

38. In whatever manner the temperament is set, the best chords are given imperfect, and this imperfection is so obvious that the common ear, entirely unskilled in music, can most readily distinguish between chords that are tempered, and those that are *tuned perfectly*. We are so constituted, however, (and wisely so, of course,) that we can get accustomed, in time, to almost any amount of discord, so that it will not be, to us, disagreeable. It is said that men, whose whole lives are spent in riveting the plates of steamboat boilers, perceive no discord in the harsh clangor of their business. Such artists would probably *prefer* a tempered organ. It is for the natural and uncontaminated, as well as for the cultivated, ear to appreciate fully the beauty and perfection of pure harmony. The best tuners, in our large manufactories are free to confess that there is but little musical satisfaction in leaving

an instrument, which has been constructed carefully in all its parts, *out of tune.*

Notwithstanding the evidence of our senses, that the perfect scale is most pleasing to the ear—notwithstanding the sure deductions from the mathematics, there are those who speak and write against perfect intonation. "Why," it is asked, "if it was intended, in nature, that music should be in *perfect tune*, has a tempered scale been used for so many centuries?" Admit such an objection, and there is an end of all invention and discovery, in this, and every other science. Against the greatest invention of the age—the electric telegraph—the same objection has equal force. So long as no mechanism had been invented, by which more than twelve sounds could be conveniently managed by the performer, we should naturally suppose that organ-builders would manufacture such instruments as we have, and give to them the best tune they could, even if it was somewhat imperfect; but we might *not* have expected, that learned and professedly scientific writers should have attempted to prove, from this fact, that the *nature of music* does not permit its chords to be in *perfect tune.** It has *not* been customary, so far as our information extends, for those who profess to treat the *natural sciences*, to charge *nature* with *imperfections*, but rather, if possible, to discover order and system, where only apparent imperfections were visible. Perhaps scientific writers on music are the only exception to this rule. These imperfections, however, belong entirely to their theories, and have no existence in the nature of music. No science—not even the mathematics—can be more *perfect* and harmonious than music, in the department which relates to intonation.

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* Prof. Peirce again says, §115, "It is a mistake to suppose, as some have done, that temperament applies only to instruments with keys and fixed scales. Singers, violin-players and all others who can pass through every gradation of tone, must all temper, or they could never keep in tune with each other, or with themselves."

"Any one, who should keep on ascending by perfect fifths, and descending by octaves and thirds, would soon find his fundamental pitch grow sharper and sharper, till he could at last neither sing nor play; and two violin-players accompanying each other and arriving at the same note by different intervals, would find a continual want of agreement."

With regard to the statement in the first paragraph, we shall now take occasion only to say, that the reverse we believe to be true; and it appears to us contradictory, to assert that singers, to sing *in tune*, must sing *out of tune*, (for this is precisely the meaning of temperament.) If the learned Professor will visit our instrument in Boston, we will satisfy him that, with our instrument as an accompaniment, which does not *temper* in the least, singers find no difficulty in keeping *in tune.*

The second paragraph probably refers to a case like the following, which has often been quoted by those who advocate temperament. "If from C we ascend by four perfect fifths and descend by two octaves and a major third, we find the last note a comma higher than the C commenced with." This is entirely true. Neither can we multiply a number by $\frac{3}{2}$'s, and divide the product by $\frac{1}{2}$'s and $\frac{4}{5}$'s, and reach at length the original number; for this reason, nevertheless, the Professor does not advocate a *temperament* in the mathematics. The supposed trouble with the violin-players who arrive at the same note, by different intervals, is, that they will *not* arrive at the *same note*, but different ones; for if one ascends from C, by *four fifths*, he will arrive at a different note from the other, who ascends from C, by a major third. The first would find himself in four sharps, while the other would be in the natural scale. The first would be playing (as we express it) E^3, the second E^2. The trouble is of the same nature as if two players should attempt to reach the same note, by ascending, one a fourth, and the other a fifth, from the same key-note. But no music requires either of these impossibilities to be done.

It was perfectly proper to treat of *temperament*, in a scientific work of this kind, as showing the best that could be done with twelve sounds, but we think it is to be regretted that imperfections should have been attributed to *music as a science*, which pertain only to the construction of musical instruments.

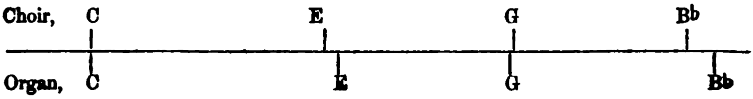
39. But melody and harmony do not produce all the effect of music, for much depends on the quality of tone, rhythm, expression, &c. It is therefore possible that tempered music may be pleasing, if good in these last particulars, although its melody and harmony be imperfect. But it is certain that, *cæteris paribus*, the more perfect the intonation, the more pleasing will be the music. The importance of absolutely perfect harmony is not equally felt in all kinds of music. In dance music, for example, the *rhythm* stands prominent, and although even here the music would be best if performed *in tune*, still, in quick movements, and in the rapid flight of notes, the attention is diverted from the imperfection in the intervals.

40. Church music, perhaps more than any other, depends, for its excellence, almost entirely upon its *harmony*. From church music, are necessarily excluded many qualities which add much interest and character to other kinds of music. As its movement is slow and regular, any excellence or defect in its harmony is most apparent. The instrument which has long been used, and is best adapted as a guide and accompaniment to voices in church music is *the organ*. For this purpose it is *the instrument* of all instruments, as its derivation (τὸ ὄργανον) also signifies. It is superior to all others, in the volume of sound and number of parts which can be brought under the control of a single player—it excels in keeping in tune, and can sustain steadily its sounds for any length of time—it will give its sounds, also, with a certainty which even violins cannot always attain. For although these stringed instruments admit of perfect intonation, yet it requires a skill, which very few artists possess, of always striking at once the desired note. The exact relative pitch of every pipe in the organ can be adjusted by the tuner at his leisure, so that (with proper precautions) he may be sure of its sound whenever it is used. If the tuner leaves an interval false, it is beyond the power of the organist to improve it; in this respect, the violin has an advantage over the organ, for if a string of the violin fall from its true pitch, skill of the artist, in execution, can overcome the difficulty.

41. *Perfect tune* has been for centuries the great desideratum in the organ and instruments of this class. In the tempered organ, the tuner leaves no chord, except the octave, in perfect tune, and

hence whatever the best organist attempts, must be imperfectly done. So long as the organ is used only as a solo instrument, as for a voluntary, a skillful performer is able in some degree to cover up the great imperfection in its tune. By great rapidity of movement, and incessant and startling transitions from key to key, he may divert the ear from criticising the imperfection of the chords. Temperament has doubtless done much to form a style, so prevalent at present among organ players and composers for that instrument—a style neither dignified nor scientific. Organists and composers are not to be blamed for this faulty style, (or a style which *would* be faulty, if their instruments could play in tune;) for being unable to obtain legitimate harmony, and satisfy themselves, or their hearers, with dignified compositions—which show most conspicuously the defects of a tempered instrument—they resort to other expedients to please, and they astonish their hearers with remote and wonderful modulations, and feats of execution.

42. When played with the choir the defects of the organ are most perceptible. As the organ usually plays the same parts which the choir sing, the singers must temper exactly like the organ—which probably no choir was ever trained to do accurately—or there will be a continued want of agreement between them. A *perfect* major third, a child, who has had no musical instruction, will strike most readily and almost unconsciously, for it is in the simple ratio of 4 : 5, and the ear instantly detects the coincidence of the vibrations; but a *tempered* major third, *two-thirds of a comma sharp*, he knows nothing about; it requires the skill of a scientific and well-drilled musician, to give it correctly. If the singers could learn to temper with the organ, it would be at the sacrifice of that pure harmony which they would make if they sung in tune without a tempered accompaniment. The ordinary agreement, (or rather *dis*agreement,) between a choir and organ accompaniment, can be illustrated to the eye by the following example. We will suppose that an organ, tuned in the equal temperament, is accompanying a choir, when it is singing the common chord of C.



The key-note of C will, of course, be the same in the organ and the choir. The fifth G, of the organ will be slightly, but percetibly, flat, viz., one twelfth of a comma. The third E, of the organ, will be very discordant with the choir, being two-thirds of a comma sharp. If B♭, in the chord of the seventh, be added, the discord will be much greater than in either the fifth or the third, the organ being a comma and a quarter too sharp.* The discord is more conspicuous when the organ plays the vocal parts, as above, than when it plays a separate accompaniment, as is sometimes done. A tempered instrument, as a piano-forte, may be properly used in this manner, as an accompaniment only, without impairing materially the perfection of a melody, which is sung by a voice.

43. For many reasons, some of which we have stated, it has long been believed by musicians, that if the organ could be constructed to play in *perfect tune*, and could be managed by the organist, it would be exceedingly valuable for aiding the songs of sacred praise in our churches. It would afford to singers a certain guide and test, and would harmonize perfectly with their voices, when they sing in a manner most satisfactorily to themselves and to all who hear. Having ascertained the notes which are necessary to perfect a requisite number of scales, it would not be difficult to construct an organ with pipes which will give all these sounds, and a wind-chest containing the proper number of valves. But these sounds must be under the ready control of the organist, or the instrument is impracticable. If we represent each sound, on the key-board, by a separate finger-key, an insuperable difficulty in execution presents itself; and it is useless to talk of what the key-board *might* have been made originally. Universal custom has fixed the key-board, and it would be as impossible now to change it, as to introduce a radical change in the orthography of our language. It remains, therefore, to invent such mechanism that the organist, with a common key-board, can conveniently control the sounds which are required to perfect every musical scale, in which the instrument plays. As these difficulties of mechanism have been successfully overcome recently in an instrument, to which allusion has already been made, a brief notice of it may be proper in this place.

44. This instrument, the EUHARMONIC ORGAN, invented and built by Joseph Alley of Newburyport, Mass., and the writer of this paper, is now set up in Boston, and will be exhibited, with pleasure, to all who may take an interest in the progress of musical science. It plays perfectly within the limits of five sharps and five flats, both inclusive. The theory of the instrument renders it perfectly practicable to construct one of any size, or compass of modulation, even to twenty sharps and twenty flats, if de-

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* Any one, who will notice the singing of a good quartette with a tempered organ, may perceive the variation and discord of the organ upon these thirds and sevenths, particularly the last. For this reason these notes are oftentimes omitted, as in chants, to the great improvement in the general effect. Good natural singers, who give their thirds and sevenths correctly, on first singing with an organ, have been accused by organists and conductors ignorant of the matter, of singing *flat*, because by temperament these notes on the organ were *too sharp*.

sired; but it is very rare that we meet, in church music, with a more remote modulation than is provided for in this instrument. The key-board, and the method of fingering, are the same as on the common tempered organ, and the only addition to the player's duties, is the management of certain pedals which must occasionally be pressed, when the music modulates into a different key. The object of these pedals is to enable one finger-key to open either of two or more valves. For example, if the C♯ (or D♭) finger-key be pressed when the music is in the scale of *one flat*, the note wanted is C♯^{1} the leading note to D minor, (see the table;) but if the music is in the scale of *four flats*, a different note, D♭^{2}, is wanted and is given by the same finger-key. The A finger-key opens, in the scale of C, the valve to A^{2}, and the same finger-key opens, in the scale of G, the valve to the pipe A^{3}. These pedals are equal in number to the scales or *signatures* in which the organ is designed to play—each pedal belongs to a certain signature, and they are arranged in their natural order, as follows:

MODULATION PEDALS,

&c., 5♭, 4♭, 3♭, 2♭, 1♭, ♮, 1♯, 2♯, 3♯, 4♯, 5♯, &c.

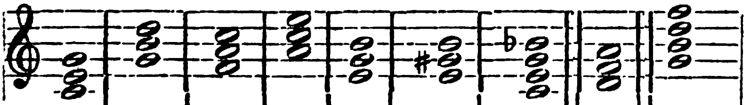
By pressing any one of these pedals, the action is brought into such a position, that the finger-keys will act on those valves (and no others,) which are required in the scale to which the pedal belongs. The act of putting down any pedal will always draw up any other which may be down at the time, and will detach from the finger-keys every valve not wanted in the scale required.

45. To illustrate the practical operation of the organ, we will take a tune, which is entirely in one diatonic scale, as the "Hundredth Psalm" in the key of G. On putting down the 1♯ pedal, the organ is in readiness to play. The valves of the pipes belonging to the scale of G, are connected with the proper finger-keys, and all others are detached; consequently, the playing of this composition on the euharmonic, will be the same as on the common organ. This however is a simple illustration, and before we explain a more complicated one, we must speak further of the plan of the instrument.

46. As but seven, of the twelve, finger-keys are employed to play the diatonic scale in each key, to the remaining five finger-keys are brought on and attached, by the same pedal and at the same time, five other notes, which are set down in the table as "leading notes of the minor scales" and "perfect sevenths," and three others which belong to the adjoining scales. In each pedal will be found the following chords, viz., the tonic, the dominant, and subdominant—the chord of the relative minor (the sixth of the scale,)—the chord of the mediant (the third,)—the major chord of the dominant of the relative minor—and the chord of the sev-

enth upon the tonic. So long as a composition uses no other chords than these, there will be no necessity, of course, to change the pedal. But most compositions either modulate into the adjoining key, (usually the dominant,) or at least pass into an adjoining scale, by using chords which belong to that scale. When a complete modulation is made, it is so apparent in the written music, that no musician of ordinary intelligence can fail to know it. But as certain chords are *borrowed* from an adjoining scale, without a complete modulation being made, and without the change being indicated by accidentals, the whole difficulty in playing the organ, will be in not understanding when these chords occur. A little attention to this point will make it perfectly clear.

47. The chords referred to are only two, viz., the *chord of the relative minor of the subdominant*, and the *chord of the dominant seventh.* The first chord will be found in the *subdominant* pedal—the first pedal to the left; the second will be found in the *dominant* pedal—the first pedal to the right. Examples of the chords we will write in the key of C, including the two last, which would be likely to occur in a composition in that key; we will write also the notes, which compose each chord, and the pedals in which each are found. The chord of the relative minor of the subdominant, is founded, *not* upon the *second* of the scale, but upon the *sixth of the subdominate scale*, which note is a comma lower than the second of the scale, and is called the *grave second;* and this chord is called, for brevity, the *chord of the grave second.* In the example, it will be seen that the only reason for pressing the F pedal is to change the second of the scale of C, viz., D^2, into the *grave second*, D^1, the sixth of the scale of F. Again, in the chord of the dominant seventh, the G pedal is put down to change the fourth of the C scale, F^2, into the perfect seventh of the G scale, F^7.



C	PEDAL	. . .	. .	. .	. . .	. . .	F PED	G PED.
						$B\flat^7$		F^7
G^2	D^2	C^2	E^2	B^2	B^2	G^2	A^2	D^2
E^2	B^2	A^2	C^2	G^2	$G\sharp^1$	E^2	F^2	B^2
C^2	G^2	F^2	A^2	E^2	E^2	C^2	D^1	G^2

48. All other chords, than these two, occurring in music, which require a change of pedal, are indicated in notation by *chromatics:* and it is believed that what has already been said is sufficient to enable any one, who possesses sufficient knowledge to play the common organ understandingly, to play the euharmonic organ.

That many who now assume to play the organ in our churches, would find difficulty in playing their music and making the requisite changes with the pedals, we have not the shadow of a doubt. To such we would recomend a course of study, on the scientific principles of music; but that any intelligent organist can readily make these changes, after a few hours' practice, has now been abundantly demonstrated. By practice, the organist will find that the music can be played with much fewer changes of pedals than he would probably make at first. He will find, for instance, that when the dominant seventh is followed by the tonic chord, it will not be necessary to change to the tonic pedal, as both chords are in the dominant pedal. It will be found, again, that the change of pedal, which would otherwise be requisite, to perfect the chord of *grave second*, can be dispensed with, by an arrangement in one action, provided for that purpose. As the first finger-key, below that used for the *second* in the scale, is unemployed, we have attached to it the *grave second*, which is a comma lower than the *second*. When therefore this *grave second* is required, it may be obtained, without touching the pedal, by placing the finger on the first key below the one which gives the *second*. It can be obtained also by the usual fingering—if the player prefers—by changing the pedal as before directed. To obtain the *grave second* of the C scale, viz., D^1, we either touch the D♭ finger-key, which is first below the second, D^2, or we put down the F pedal and touch the D finger-key. Each scale is furnished, in like manner, with its *grave second*.

49. The action—which is the chief mechanical peculiarity in the construction of the organ, and on which the patent is founded—is of such a nature, that it operates as perfectly in practice as we designed it in theory, and it is so substantial in its construction, that it will bear almost any amount of use, and stand almost any number of years, without getting out of order, or needing repairs. It can be applied to the largest instruments, as those which contain the four organs, viz., the Great, the Swell, the Choir, and the Pedal Organs; a single set of pedals will operate, as described, upon the whole at once.

Much of this paper we have devoted to considering, *what sounds are necessary to a certain number of perfect scales?* On these points we have asked not so much, what is *authority?* as, what is *truth?* We have been compelled to differ from teachers in this science, to whom we look up with veneration and respect. So far as our views on these points are original, we commit them, without anxiety, to the world, to share such a fate as their merits deserve. But a distinction must be made between our *theory*, and our *invention*. The value of our invention will not be endangered even if our theory of the musical scale should fail. Our instrument plays the scale which we believe to be correct.

Our mechanism, however, is as well adapted to play any other scale, as the one we have adopted.

The ostensible design of our invention is to produce harmony; but even those who delight in *discord*, can find, in our instrument, a source of attraction. By putting down the modulation pedal belonging, for instance, to the scale of E, and playing in the scale of A♭, they will be furnished with an amount of discord, to which our common tempered instruments bear but a faint approximation. To express the effect, the ordinary term of "wolf" is weak. If this effect be too severe, any less amount of discord, or *temperament*, can be obtained by putting down a less remote modulation pedal. Discords have their appropriate place in music, but their place is *not* in a common chord, or where the composer designed a concord. In such combinations many love *pure* HARMONY, and we are among that number; this can be obtained by putting down the modulation pedal belonging to the scale in which the music is written.

50. As reference has been made to the organ of the Rev. Henry Liston, and also to errors (as we consider them,) in his plan, we will now, as we promised in the early part of this paper, speak of his plan, and show also, in what particulars the two instruments resemble each other. They both had for their object PERFECT TUNE. Both Mr. Liston and ourselves investigated, independently, and *ab integro*, the phenomena of music, to ascertain what sounds were necessary to a requisite number of perfect musical scales. We necessarily arrived at many and the same truths; in several respects also we differed; indeed, our plan was perfected, and the instrument partly completed, before we saw Mr. Liston's Essay.* When we come to the mechanism for carrying into operation our separate plans, all resemblance ceases. In the theory of the two instruments, the great difference is found in the *perfect seventh*, 4 : 7, in the chord of the seventh, for which Mr. Liston made no provision, but used, in its place, the fourth of the scale, 9 : 16. This combination is very discordant, and, when the *ninth* is added, (17.) is so harsh, that in Mr. Liston's opinion, the ninth ought not to be used with the seventh in this manner. Again, he has the major and minor keys of the same letter—as C major and C minor—founded upon the *same key-note* (27.); and he makes the major third of C the key-note of *four sharps*, &c.—thus destroying the *series of perfect fifths* by which the keys should be connected together. In the mechanism

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* We take this opportunity to express our acknowledgment to Dr. Edward Hodges, Musical Director of Trinity Church, New York, for his kindness in voluntarily forwarding to us Mr. Liston's Essay, which is very rare; as it was published by subscription, and only a few copies were printed. We would moreover express to Dr. Hodges, and also to Prof. E. T. Fitch, of Yale College, our thanks for their sympathy and encouragement, when our plans had not so many friends as at present.

there is scarcely a point of resemblance, either in its internal structure or its management by the player. We cannot be expected here to give a description of our machinery, further than is necessary to understand the method of playing it, as it would require drawings to make it intelligible; and besides, we have already, we fear, exhausted the patience of our readers. On our organ, a single pedal will bring on an entire scale, extending through every set of pipes in the instrument, and the operation of the pedals is the same in every key. On Mr. Liston's organ, different keys required different combinations of pedals, with different degrees of difficulty. All the notes of some diatonic scales could not be brought on together by any combination of pedals, as for instance, in the scale of G, the organist could not obtain its second, A^3, and its sixth, E^2, at the same time; for when A^3 was brought on, E^3 always came with it, and A^2 always accompanied E^2.

51. The practicability, therefore, of building an organ which will give its chords in perfect tune, and can be easily managed for all music that is proper for the services of the church, is no longer a matter of speculation and doubt. The organ we have spoken of, has been in constant use for nine months, and has kept in perfect order. Good singers, whose ears have not been accustomed to a tempered accompaniment, agree with it perfectly, giving readily and naturally, all the intervals necessary to Perfect Intonation. Those who have been accustomed to sing with a common organ, require some practice before they have corrected their old habits, they are then prepared to appreciate the distinction between the pure harmony of nature and the discordant harmony of art.

52. Although we have not intended the organ for any music except such as *can be sung*, yet, if any one should write music very difficult, on account of its abrupt transitions from key to key, as for instance, from the key of C to four sharps, thence, straightway into four flats, &c., the music nevertheless can be played if the organist understands it. But probably no singers could sing such a composition without a guide, and any such music, (if any such there be) which cannot be played on the euharmonic organ, is certainly very far beyond the ability of singers to sing. In such music as a leader of good taste would select, the small addition to the duties of the organist is not sufficient to embarrass one of ordinary musical knowledge and skill, and for this extra care he will be richly repaid by the improvement in the harmony. Those who have *felt* the effect of perfect harmony, in the music of a quartette of natural and well drilled singers or violin-players, can form an idea of the harmony of the organ when in perfect tune. In training singers in correct intonation, this organ affords an aid which is invaluable; and to violin-players, it affords a certain guide for stopping their notes in tune.

53. We should not be treating the whole subject, if we did not speak of the relative *expense* of building the enharmonic organ. It can truly be said to be *more expensive*, at the same time, *more economical*, than the common organ. The extra machinery and pipes in this organ render it *more expensive;* its effect, and the musical satisfaction (which is the sole object of the organ, or any musical instrument) derived at a given outlay of money, renders it the *more economical.* The euharmonic organ of a given size and expense, would not contain as many sets of pipes or "stops," as each stop contains more pipes than the common organ, yet each set or *stop* is more effective, in power, than the same stop would be if tempered; for it is well known that musical sounds, which are in harmony, assist and strengthen each other, while discordant sounds neutralize and destroy each other. Besides, a great quantity of *mere sound* will no more afford musical pleasure, than mere painted canvas will satisfy the lover of painting. Church committees, who purchase organs, are not aware (as we organ-builders *could* inform them) that much which they pay for, is *mere trickery and trumpery.* There is, however, a desire, *in* the church, as well as *out* of it, to boast of an organ having as large a number of stops as possible, even if many of these furniture and reed stops, (having foreign names, which they do not understand,) are as inappropriate for the legitimate purposes of church music as a set of Chinese gongs. So long, however, as such a rivalry exists, and such instruments are ordered and paid for, they will be built; for this is the business of organ-builders. It is probable that any one who loves music at all, would prefer the music of a quartette of good singers, to a noisy chorus of fifty, singing no nearer in tune than the tempered organs play. As has been before stated, the theory of the instrument admits it to be of any size and power—the expense to be appropriated, must alone decide that point. This, however, can be stated with certainty, that a euharmonic organ in *perfect tune* and of sufficient size and power to perform satisfactorily the purposes of an organ in church, can be built for the expense which is usually appropriated to the larger class of instruments of *imperfect tune.*

54. Until it had been shown to be practicable by experiment, it was to be expected that a conservative portion of the public would view, with caution, a plan like the present, which proposes such a radical reformation in a system of so long standing as the organ scale. This feeling certainly operated against the plan when we proposed to undertake it two years since. It is with no little gratification that, since the completion of the instrument, it has had the favorable and unanimous opinion of the musical people who have examined it, and the scientific principles on which it is built. We believe it is certain that public musical opinion,

will ere long, among other improvements in the music of our churches, demand that it be given in *pure harmony*, and in accordance with the fixed and demonstrable principles of music.

That music may be investigated with something of the same learning and research which is bestowed upon almost every other science, is an end much to be desired. It will be gratifying to the writer—even if some of his opinions are shown to be incorrect—if his labors in this department of science, shall have the effect of calling to this subject the attention of those who are better qualified to make further investigations, and who can lay them before the public in a more interesting manner.

Note.—In the music example in (18.) page 77, the second lower note in the base clef, should be B♭ instead of D; and the ♭ also should have been placed on the second, instead of the third line. We would here also state that this and several other music examples in this paper were intended as theoretical illustrations, rather than as examples for actual execution.

Art. XXIII.—*On the new American Mineral, Lancasterite;*
by Prof. B. Silliman, Jr.

Among the minerals associated with the Serpentine of Texas, Lancaster Co., Pennsylvania, received through the kindness of Mr. L. White Williams of Westchester, one has close resemblance to Brucite. On chemical examination it has proved to be a new hydrous carbonate of magnesia, for which I propose the name *Lancasterite*. The following are its characters:—

Foliated like Brucite, affording thin pearly laminæ, inelastic and somewhat flexible. Also small crystals, which appear to be monoclinic (?) with an eminent pearly diagonal cleavage, H=2·5. G=2·33 according to my determinations; 2·35, according to H. Erni. Translucent. According to two analyses by H. Erni, it contains,

	1.	2.	Mean.	Oxygen.	
Carbonic acid,	27·07	26·85	26·96	19·61	1
Magnesia,	50·01	50·72	50·36	19·79	1
Protoxyd of iron,	1·01	0·96	0·99	0·21	
Water,	21·60	21·47	21·53	19·14	1
	99·69	100·00			

This gives the formula $\dot{M}g\ddot{C}+\dot{M}g\dot{H}^2$ = carbonic acid 27·11, magnesia 50·78, water 22·11=100. In two other trials the $\dot{H}$ and $\ddot{C}$ together equaled 49·83 and 49·86 after 1½ days drying in the water bath. In a matrass the mineral yields much water.

Before the blowpipe it exfoliates and becomes a little yellowish or brownish, and gives the reaction of magnesia. Dissolves with effervescence in acids.

We observe that Hermann has made a new mineral—which he calls *Pennite*—of the white and greenish incrustation of carbonate of magnesia accompanying Emerald nickel at Texas, Pa., and which, as we have remarked, appears to graduate into the Emerald nickel. He finds for its composition, carbonic acid 44·54, lime 20·10, magnesia 27·02, nickel 1·25, protoxyd of manganese 0·40, alumina 0·15, water 5·84 = 100, giving the formula $3(\dot{\text{Mg}}, \dot{\text{Ca}}, \dot{\text{Ni}})\ddot{\text{C}}+\text{Ħ}$. H = 3·5. G. = 2·86.

We have not yet had opportunity for trials to ascertain how far the water is a constant ingredient.

Art. XXIV.—*Table of Atomic Weights.*

The recent investigations of science, while evincing the consummate skill of the Swedish chemist, are introducing changes from time to time in the Berzelian atomic weights. These changes are in part the result of *direct* experiment on the particular substances, and in part an *indirect* consequence of these new determinations;—a change of one element involving necessarily a change in those other elements which were determined by using that one in the data. The following table is here inserted as an exposition of the recent results, only a part of which have hitherto appeared in this Journal, and these at distant intervals. In order to render it useful and convenient to the chemist, there are added to it the more common oxyds and sulphurets, and also the oxygen or sulphur per-centage for these compounds.

Hydrogen is taken as a single instead of a double atom, as this appears to be becoming the accepted mode among chemists. In the same manner, chlorine, iodine, bromine, phosphorus, nitrogen, arsenic and antimony, are written as single atoms or equivalents, with double the Berzelian atomic weight.

The multiples of the atomic weights of many of the oxyds are also given, as they save time and trouble, besides rendering accuracy in calculations more certain.

Various authorities are annexed, and different determinations for many of the elements, in order to give the means of comparison and choice to such as would use them, and especially for comparison with the new determinations that may hereafter be made.

The number of elements as now recognized is sixty-two, forty-nine of which are metals. J. D. D.

Aluminium, Al,	170·9	
Alumina, $\dddot{\cancel{\text{Al}}}$,	641·8	(O, 46·74)
2 $\dddot{\cancel{\text{Al}}}$	1283·6	
3 $\dddot{\cancel{\text{Al}}}$	1925·4	
4 $\dddot{\cancel{\text{Al}}}$	2567·2	
5 $\dddot{\cancel{\text{Al}}}$	3209·0	
6 $\dddot{\cancel{\text{Al}}}$	3850·8	
Antimony (Stibium), Sb,	1612·9	
Sul. Antim., Sb S^3,	2212·9	(S, 27·12)
Argentum (Ag) see *Silver*.		
Arsenic, As,	937·50*	*Pelouze.*
Arsenic Acid, $\overset{\cdot\cdot\cdot\cdot\cdot}{\text{As}}$,	1437·5	(O, 34·78)
Sulphuret of A., As S^3,	1537·5	(S, ·39·0)
Aurum (Au) see *Gold.*		
Baryum, Ba,	856·8†	
Baryta, $\dot{\text{Ba}}$,	956·8	(O, 10·45)
2 $\dot{\text{Ba}}$	1913·6	
3 $\dot{\text{Ba}}$	2870·4	
4 $\dot{\text{Ba}}$	3827·2	
Beryllium (Be) see *Glucinum.*		
Bismuth, Bi,	1330·4	
Oxyd of Bismuth, $\dddot{\cancel{\text{Bi}}}$,	2960·8	(O, 10·13)
Boron, B,	136·2	
Boracic Acid, $\dddot{\text{B}}$,	436·2	(O, 68·78)
Bromine, Br,	1000‡	
Cadmium, Cd,	696·8	
Calcium, Ca,	251·49§	*Berz.*
Lime, $\dot{\text{Ca}}$,	351·49	(O, 28·45)
2 $\dot{\text{Ca}}$	702·98	
3 $\dot{\text{Ca}}$	1054·47	
4 $\dot{\text{Ca}}$	1405·96	
5 $\dot{\text{Ca}}$	1757·45	
6 $\dot{\text{Ca}}$	2108·94	
Carbon, C.	75	*Dumas.*
Carbonic Acid, $\ddot{\text{C}}$,	275	(O, 72·73)
2 $\ddot{\text{C}}$	550	
3 $\ddot{\text{C}}$	825	
4 $\ddot{\text{C}}$	1100	
5 $\ddot{\text{C}}$	1375	
6 $\ddot{\text{C}}$	1650	
Cerium, Ce,	575‖	*Hermann.*
Protoxyd of C. $\dot{\text{Ce}}$,	675	(O, 14·82)
Peroxyd of Cerium, $\dddot{\cancel{\text{Ce}}}$,	1450	(O, 20·69)
Chlorine, Cl.	443·3	
Hydrochlor. Acid, HCl,	455·8	

Chromium, Cr,	328·4¶	*Berlin.*
Oxyd of Chrome, $\dddot{\cancel{\text{Cr}}}$,	956·8	(O, 31·35)
Chromic Acid, $\dddot{\text{Cr}}$,	628·4	(O, 47·74)
Cobalt, Co,	368·65	
Oxyd of Cobalt, $\dot{\text{Co}}$,	468·65	(O, 21·34)
Columbium (Tantalum) Ta,	1148·4	
Columbic Acid, $\dddot{\cancel{\text{Ta}}}$,	2596·8	(O, 11·55)
Copper (Cuprum), Cu,	396.6	
Oxyd of Copper, $\dot{\cancel{\text{Cu}}}$,	893·2	(O, 11·2)
Oxyd of Copper, $\dot{\text{Cu}}$,	496·6	(O, 20·14)
Didymium, D,	620 ?	*Marignac.*
Erbium, Eb,		
Ferrum (Fe) see *Iron.*		
Fluorine, F,	237·5	*Louyet.*
Hydrofluoric Acid, FH,	250·0	(F, 95)
Glucinum (Beryllium), Be,	58·084**	*Awd.*
Glucina, $\dot{\text{Be}}$,	158·084	(O, 63·26)
Gold (Aurum), Au,	2455††	
Hydrargyrum (Hg) see *Quicksilver.*		
Hydrogen, H,	12·5‡‡	
Water, $\dot{\text{H}}$,	112·5	(O, 88·89)
2 $\dot{\text{H}}$	225·0	
3 $\dot{\text{H}}$	337·5	
4 $\dot{\text{H}}$	450·0	
5 $\dot{\text{H}}$	562·5	
6 $\dot{\text{H}}$	675·0	
7 $\dot{\text{H}}$	787·5	
8 $\dot{\text{H}}$	900·0	
9 $\dot{\text{H}}$	1012·5	
Iodine, I,	1586	
Iridium, Ir.	1232	
Iron (Ferrum), Fe,	350§§	
Protoxyd of Iron, $\dot{\text{Fe}}$,	450	(O, 22·22)
2 $\dot{\text{Fe}}$	900	
3 $\dot{\text{Fe}}$	1350	
4 $\dot{\text{Fe}}$	1800	
5 $\dot{\text{Fe}}$	2250	
6 $\dot{\text{Fe}}$	2700	
Peroxyd of Iron, $\dddot{\cancel{\text{Fe}}}$,	1000	(O, 30)
Kalium (K) see *Potassium.*		
Lanthanum, La,	588‖‖	*Marignac.*
Protoxyd of L., $\dot{\text{La}}$,	688	(O, 14·55)
Peroxyd of L., $\dddot{\cancel{\text{La}}}$.	1476	(O, 20·33)
Lead (Plumbum), Pb,	1294·6	
Oxyd of Lead, $\dot{\text{Pb}}$.	1394·6	(O, 7·17)

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* 938·8, *Berzelius.*

† 854·85, *Berzelius*, taking chlorine at 443·20, and silver at 1349·01.—858·08, *Pelouze*; 856·77, *Marignac.*

‡ 999·98, *Marignac.*

§ 250, *Dumas*, and *Marchand and Erdmann.* This gives for $\dot{\text{Ca}}$ 350 (O, 28·57).

‖ 572·8, *Rammelsberg*; 576·97. *Beringer*; more recent, (1849), 590·8, *Marignac*, which gives for $\dot{\text{Ce}}$ 690·8 (O, 14·48), and for $\dddot{\cancel{\text{Ce}}}$, 1481·6 (O, 20·25).

¶ More recently 334, *Moberg*, which gives for $\dddot{\cancel{\text{Cr}}}$ 968 (O, 31); and for $\dddot{\text{Cr}}$ 634 (O, 47·3).

** According to Kobell and Awdejew, glucina is a protoxyd. Yet some distinguished chemists still consider it a peroxyd, like alumina; making glucinum (Be) 331·26, and glucina ($\dddot{\cancel{\text{Be}}}$) 962·52 (O, 31·17); or Be 87·12 and $\dddot{\cancel{\text{Be}}}$ 474·24, *Berz.*

†† 1227·75, *Berz.*, corrected by Pelouze for the new atomic weight of quicksilver. *Pelouze* has recently obtained 1227·45. Most chemists now double this number as above.

‡‡ 12·48, *Berzelius.*

§§ 350·527, *Berzelius*; more recently, 349·8, *Svanberg* and *Norlin.*

‖‖ 554·88, *Rammelsberg*; 600, *Hermann*; 580, *Mosander.* The last is a mean of the different determinations, and gives for $\dot{\text{La}}$ 680 (O, 14·7), and for $\dddot{\cancel{\text{La}}}$ 1460 (O, 20·55).

Lime, see *Calcium.*		
Lithium, Li,	81·66	
Lithia, $\dot{\mathrm{Li}}$,	181·66	(O, 55·05)
Magnesium, Mg,	154·5[*]	*Svanb.*
Magnesia, $\dot{\mathrm{Mg}}$,	254·5	(O, 39·3)
2 $\dot{\mathrm{Mg}}$	509·0	
3 $\dot{\mathrm{Mg}}$	763·5	
4 $\dot{\mathrm{Mg}}$	1018·0	
5 $\dot{\mathrm{Mg}}$	1272·5	
6 $\dot{\mathrm{Mg}}$	1527·0	
Manganese, Mn,	344·7	
Protoxyd of M., $\dot{\mathrm{Mn}}$,	444·7	(O, 22·47)
2 $\dot{\mathrm{Mn}}$	889·4	
3 $\dot{\mathrm{Mn}}$	1334·1	
4 $\dot{\mathrm{Mn}}$	1778·8	
Peroxyd of M., $\dddot{\overline{\mathrm{Mn}}}$,	989·4	(O, 30·32)
2 $\dddot{\overline{\mathrm{Mn}}}$	1978·8	
3 $\dddot{\overline{\mathrm{Mn}}}$	2968·2	
4 $\dddot{\overline{\mathrm{Mn}}}$	3957·6	
Mercury (Hg) see *Quicksilver.*		
Molybdenum, Mo,	575·83[†]	*Svanb.*
Molybdic Acid, $\dddot{\mathrm{Mo}}$.	875·83	(O, 34·3)
Natrium (Na) see *Sodium.*		
Nickel, Ni,	369·33	
Protoxyd of Nickel, $\dot{\mathrm{Ni}}$,	469·33	(O, 21·3)
Niobium, Nb,		
Nitrogen, N,	175·06	
Nitric Acid, $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$,	675·06	(O, 74)
2 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$	1350·12	
3 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$	2025·18	
4 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$	2700·24	
Norium,		
Osmium, Os,	1242·6	
Oxygen, O,	100	
Palladium, Pd,	665·48	
Pelopium,		
Phosphorus, P,	392[‡]	*Berz.*
Phosphoric Acid, $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$,	892	(O, 56·05)
2 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$	1784	
3 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$	2676	
4 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{P}}$	3568	
Platinum, Pt,	1232·08	
Plumbum (Pb) see *Lead.*		
Potassium (Kalium), K,	488·86[§]	
Potassa, $\dot{\mathrm{K}}$,	588·86	(O, 16·98)
2 $\dot{\mathrm{K}}$	1177·72	
3 $\dot{\mathrm{K}}$	1766·58	
4 $\dot{\mathrm{K}}$	2355·44	
Quicksilver (Hydrargyrum), Hg,	1250[‖]	
Rhodium,	651·96	

Ruthenium, Ru,	*undetermined.*	
Selenium, Se,	495·3[¶]	
Silicium, Si,	277·31[**]	*Berz.*
Silica, $\dddot{\mathrm{Si}}$,	577·31	(O, 51·96)
2 $\dddot{\mathrm{Si}}$	1154·62	
3 $\dddot{\mathrm{Si}}$	1731·93	
4 $\dddot{\mathrm{Si}}$	2309·24	
5 $\dddot{\mathrm{Si}}$	2886·55	
6 $\dddot{\mathrm{Si}}$	3463·86	
7 $\dddot{\mathrm{Si}}$	4041·17	
8 $\dddot{\mathrm{Si}}$	4618·48	
9 $\dddot{\mathrm{Si}}$	5195·79	
Silver (Argentum), Ag,	1350[††]	
Sulphuret of S., AgS,	1550	(S, 12·9)
Sodium (Natrium), Na,	287·2[‡‡]	
Soda, $\dot{\mathrm{Na}}$,	387·2	(O, 25·83)
2 $\dot{\mathrm{Na}}$	774·4	
3 $\dot{\mathrm{Na}}$	1161·6	
4 $\dot{\mathrm{Na}}$	1548·8	
Stannum (Sn) see *Tin,*		
Stibium, (Sb) see *Antimony.*		
Strontium, Sr,	548[§§]	*Pelouze.*
Strontia, $\dot{\mathrm{Sr}}$,	648	(O, 15·43)
Sulphur, S,	200[‖‖]	
Sulphuric acid, $\dddot{\mathrm{S}}$,	500	(O, 60)
Tantalum (Ta) see *Columbium.*		
Tellurium, Te,	801·8	
Terbium, Tb,		
Thorium, Th,	743·86	
Thoria, $\dot{\mathrm{Th}}$,	843·9	(O, 11·84)
Tin, (Stannum), Sn,	735·3[¶¶]	
Oxyd of Tin, $\ddot{\mathrm{Sn}}$,	935·3	(O, 21·38)
Titanium, Ti.	314·7[***]	
Oxyd of Titanium, $\dddot{\overline{\mathrm{Ti}}}$,	929·4	(O, 32·28)
Titanic Acid, $\ddot{\mathrm{Ti}}$,	514·7	(O, 38·86)
Tungsten (Wolframium) W,	1188·4	
Tungstic Acid, $\dddot{\mathrm{W}}$,	1488·4	(O, 20·16)
Uranium, U,	750[†††]	*Peligot.*
Protoxyd of U., $\dot{\mathrm{U}}$,	850	(O, 11·76)
Peroxyd of U., $\dddot{\overline{\mathrm{U}}}$,	1800	(O, 16·66)
Protoperox. of U., $\dot{\mathrm{U}}\dddot{\overline{\mathrm{U}}}$,	2650	(O, 15·10)
Vanadium, V,	856·9	
Water, see *Hydrogen.*		
Wolframium (W) see *Tungsten.*		
Yttrium, Y,	402·5	
Yttria, $\dot{\mathrm{Y}}$,	502·5	(O, 19·90)
Zinc, Zn,	406·6	*Erdmann.*
Oxyd of Zinc, $\dot{\mathrm{Zn}}$,	506·6	(O, 19·74)
Zirconium, Zr,	419·73	
Zirconia, $\dddot{\overline{\mathrm{Zr}}}$,	1139·5	(O, 26·3)

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[*] 158·14, *Berzelius;* 151·33, *Scheerer.*

[†] 596·1, *Berzelius*, revised.

[‡] 400·10, *Pelouze.*

[§] 488·856, *Berzelius;* 487·004, *Maumené.*

[‖] 1247·33, 1248·21, 1249·27, *Svanberg;* 1250·6, *Erdmann and Marchand;* 1250, (nearly a mean of these determinations), *Millon;* 1251·29, *Berz.*

[¶] 491, Sacc.

[**] 266·742, *Pelouze*, more recent; 277·778, *Berzelius* revised.

[††] 1349·66, *Berzelius;* 1349·01, *Marignac;* 1350·32, *Maumené.*

[‡‡] 287·17, *Pelouze;* 290·9, and later revision, 289·73, *Berzelius.*

[§§] 545·93, *Berz.*

[‖‖] 200·75, *Berzelius*, making sulphuric acid 500·75 (O, 59·91); 200·02, *Erdmann and Marchand*, considering 1250·6, the equivalent for quicksilver.

[¶¶] Recently, 725, *Mulder.*

[***] 301·55, *Berzelius;* 303·3, *H. Rose;* 295·8, *Mosander;* 314·69, *Pierre.*

[†††] 746·34, *Wertheim;* the earlier results give 2711·4, making $\dddot{\overline{\mathrm{U}}}$=5722·72 (O, 5·24).

ART. XXV.—*On the Isomorphism and Atomic Volume of some Minerals*; by JAMES D. DANA.[*]

HAVING perused recent statements by Prof. G. Rose respecting some anomalous cases of isomorphism, and also having remarked that the chemically unlike minerals chrysoberyl and chrysolite were essentially alike in form, I was led to a farther search for such singular anomalies among minerals in order to elicit the principle upon which they depend. The results of the investigation have proved interesting beyond what was expected, and are detailed in the following pages.

Before proceeding with them, the facts observed by Prof. Rose should be mentioned. He points out the relations of bismuth, arsenic and some other metals,[†] and also shows that specular iron and alumina are isomorphous with them, as seen in the following table.

Osmium,	R : R=84°52′	Bismuth,	R : R=87°40′
Iridium,	84 52	Palladium,	undetermined.
Arsenic,	85 04		
Tellurium,	86 57	Corundum (alumina) $\dddot{\bar{\mathrm{Al}}}$	R : R=86 4
Antimony,	87 35	Specular iron ($\dddot{\bar{\mathrm{Fe}}}$)	85 58
		Titanic iron ($\dddot{\bar{\mathrm{Fe}}}$, $\dddot{\bar{\mathrm{Ti}}}$)	85 59

Prof. Rose also gives the following parallel groups of isomorphs.[‡]

1. *Form that of Calc Spar.*

			R : R
a.	Calc spar and isomorphs	$\dot{\mathrm{R}}\ddot{\mathrm{C}}$	105° – 107°40′
b.	Nitrate of soda	$\dot{\mathrm{Na}}\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$	106 33
c.	Dark red silver ore	$3\mathrm{AgS}+\mathrm{SbS}^3$	108 18
	Light red silver ore	$3\mathrm{AgS}+\mathrm{AsS}^3$	107 36

2. *Form that of Arragonite* (*dimorph with the preceding*).

			M : M
a.	Arragonite, white lead ore, &c.	$\dot{\mathrm{R}}\ddot{\mathrm{C}}$	116° – 118°30′
b.	Nitrate of potash	$\dot{\mathrm{K}}\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$	119
c.	Bournonite	$3(\bar{\mathrm{Cu}}, \mathrm{Pb})\mathrm{S}+\mathrm{SbS}^3$	115 16

Many examples of this kind of isomorphism have come to light in the course of the research; and moreover an explanation is at hand in *the relations of atomic volume*—the same principle appealed to by Kopp for explaining the cases of ordinary isomorphism.

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[*] The atomic numbers adopted in the body of the preceding table have in a few instances been slightly changed, since this article was printed: in such cases, the numbers employed in the following pages will be found in the notes to the table.

[†] On the rhombohedral metals, Monatsb. der Königl. Preuss. Akad. der Wissenschaften zu Berlin, April, 1849, p. 137.

[‡] In an article "on a remarkable analogy of form between certain sulphur and oxygen salts," Monatsbericht der Köingl. Preuss. Akad. d. Wissenschaften zu Berlin, Jan., 1849, p. 13. Pogg. Annal., lxxvi, p. 291.

Rammelsberg endeavored to apply this principle in accounting for the relations of epidote and different varieties of orthite.* As is customary in such investigations, he determined the atomic volume of the compounds and compared the ascertained numbers with one another. But the relation obtained was not sufficiently simple to be wholly satisfactory. One additional step seems to throw farther light on the subject, and leads to general conclusions not otherwise apparent. This step consists simply in *dividing the aggregate atomic volume of the compound by the number of atoms of the elements present.* Unlike compounds are thus reduced to a single standard. The correctness of such a step is proved by the general correspondence obtained between likeness of form and volume. The relations between the *aggregate* atomic volume of isomorphous compounds is in many cases necessarily complex; for we find that this relation is expressed most nearly by the proportional number of molecules of elements in those compounds. Between ryacolite and loxoclase, for example, this relation is that of 15 : 19, and between labradorite and anorthite, that of 15 : 37 (see page 233).

That the subject may be fully illustrated and the facts on all sides fairly exhibited, I have in the following pages given with equal detail, (A) the aggregate atomic volume; (B) this aggregate atomic volume divided by the number of atoms of acids and bases; and (C) the same divided by the number of atoms of the elements. The peculiar interest of each of these modes of viewing the atomic volume will thus be clearly shown: and while not underrating the ratios ascertained by the *first*, we think that an additional value will be found in the relations developed by the *third* method; and also that some importance may attach to the *second*. In some cases the (B) relation is singularly close and of interest. The atomic volumes of alumina and arsenic are almost identical (161·7 and 163); while if we divided by 5, the number of atoms in alumina, it gives, instead of a ratio of equality, the ratio of 1 : 5. These modes of viewing the subject of atomic volume appear to open the way for important conclusions bearing upon some of the most recondite points in chemical science.

Hermann has written at considerable length upon isomorphism among compounds of unlike atomic constitution.† He has confined himself almost exclusively to pointing out such well known cases as the chemically unlike varieties of epidote, scapolite, etc., (which the crystallographer has often united and the chemist as often pulled asunder)—besides some acknowledged instances of isomorphism. He has introduced for such cases the new term *heteromerism*, a term of indefinite signification, since all compounds of *unlike* atomic proportions are heteromerous, whether isomorphous or not.

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* Poggendorff's Annalen, 1849, No. 1, lxxvi, p. 80.

† Erdmann und Marchand's Journal für Praktischen Chemie, xliii, 35.

Without farther introduction I proceed with the details of the observations—mentioning, first, some of the prominent cases of isomorphism among unlike compounds; and then giving the researches into the atomic volume of these and other species.

I. CHRYSOBERYL, $\dot{\mathrm{Be}}\,\bar{\mathrm{Al}}$—CHRYSOLITE, $(\dot{\mathrm{Mg}}\,\dot{\mathrm{Fe}})^3\,\dddot{\mathrm{Si}}$—SERPENTINE, $2\dot{\mathrm{Mg}}^3\,\dddot{\mathrm{Si}}^2+3\dot{\mathrm{Mg}}\,\dot{\bar{\mathrm{H}}}^2$—EPSOM SALT, $\dot{\mathrm{Mg}}\,\dddot{\mathrm{S}}+7\dot{\bar{\mathrm{H}}}$—VILLARSITE, $4(\dot{\mathrm{Fe}},\dot{\mathrm{Mg}})^3\,\dddot{\mathrm{Si}}+3\dot{\bar{\mathrm{H}}}$—PICROSMINE, $2\dot{\mathrm{Mg}}^3\,\dddot{\mathrm{Si}}^2+3\dot{\bar{\mathrm{H}}}$.

The magnesian minerals, Chrysolite, Serpentine and Villarsite, are well known to be isomorphous, and have been the subject of recent remarks by Hermann.[*] We now add the totally unlike minerals, Chrysoberyl and Epsom salt.

A brachydiagonal prism in Chrysolite has the angle 80° 53′, a corresponding one in Chrysoberyl 119° 46′. The tangents of half these angles are nearly as 1 : 2; and a vertical prism of the former has the angle 49° 50′ and one of Chrysoberyl 70° 40′, giving the relation of 1 : 1½. The former planes, referred to the same fundamental form, are respectively $\breve{P}\infty$ and $2\breve{P}\infty$, and the latter ∞P and $\infty P\frac{3}{2}$. The crystallographic axes of these species as given by von Kobell are as follows:—

	a.		b.		c.
Chrysoberyl, ...	0·58	:	1	:	0·47
Chrysolite, ...	1·1733	:	1	:	0·93

The ·93 of Chrysolite it is seen is double of ·47 in Chrysoberyl, and 1·1733 is double of 0·58 showing a simple ratio. If we take for Chrysolite the vertical prism above alluded to (49° 50′) as the prism ∞P, it gives $b:c=1:0{\cdot}465$, which is almost identical with that for chrysoberyl. We add farther, though other evidence is unnecessary, that the angles of the corresponding rhombic octahedrons in each of the above species, are given as follows:—

Chrysolite, ...	139°55′	85°15′	108°31′
Serpentine, ...	139 34	88 26	105 26
Villarsite, ...	139 45	86 56	106 52
Chrysoberyl, ...	139 53	86 16	

In Picrosmine, a brachydiagonal prism has the angle 117°49′, which is near that of Chrysoberyl, and a vertical prism the angle 53° 08′, the corresponding angle in Chrysolite being 49° 50′. This prism being the prism ∞P, it gives $b:c=1:0{\cdot}5$, while it is 1 : 0·47 in Chrysoberyl, and 1 : 0·465 in Chrysolite.

Epsom salt has the same axes as Chrysolite, except that for the assumed fundamental form,[†] the vertical axis is about one-half the above in length. The numbers given are 0·5703 : 1 : 0·9089, which on doubling the first term becomes 1·1406 : 1 : 0·9089.

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[*] J. f. Pr. Chem., 1849, xlvi, 229.

[†] It may not be understood by all my readers that the axes of crystals are not lines of fixed length for each crystal, but only the axes corresponding to a form or set of planes in the crystal *assumed* as the fundamental form—a form of frequent

II. QUARTZ, $\dddot{\mathrm{Si}}$—CHABAZITE, $(\dot{\mathrm{Ca}}, \dot{\mathrm{Na}}, \dot{\mathrm{K}})^3\dddot{\mathrm{Si}}^2+3\bar{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}^2+18\dot{\mathrm{H}}$.

R : R in Quartz = 94° 15′; in Chabazite = 94° 46′.

III. CORUNDUM, $\bar{\dddot{\mathrm{Al}}}$—PHENACITE, $\dot{\mathrm{Be}}^3\,\dddot{\mathrm{Si}}$, together with *Arsenic* and others of the group on page 220.

Taking the angle of the rhombohedron of phenacite at 115° 25′, the axis $a = 0·6958$. The axis a of Corundum = 1·3617, which is nearly double that of phenacite (2 × 0·6958 = 1·3916). The angle of the rhombohedron 2R of phenacite is 83° 12′; while R : R in corundum is 86° 4′; in Iridium 84° 52′; in Arsenic 85° 04′.

IV. SCHEELITE, $\dot{\mathrm{Ca}}\,\dddot{\mathrm{W}}$—(with TUNGSTATE OF LEAD, $\dot{\mathrm{Pb}}\,\dddot{\mathrm{W}}$ and MOLYBDATE OF LEAD, $\dot{\mathrm{Pb}}\,\dddot{\mathrm{Mo}}$)=FERGUSONITE, $\dot{\mathrm{Y}}^6\,\bar{\dddot{\mathrm{Ta}}}$.

Tungstate of lime and Fergusonite crystallize in square octahedrons which are hemihedrally modified in the same manner. In the former the angle of the octahedron is 100° 8′; in the latter a corresponding octahedron has the pyramidal angle 100° 28′. The axis of Tungsten is given at 1·05, and that of Fergusonite, (another pyramid being assumed as fundamental,) at 1·50; the latter is 1½ times the former—a simple relation. Tungstate of lead, a recognized pseudomorph of Tungsten, has A : A = 99° 43′, and Molybdate of lead, also so recognized, has A : A = 99° 40′.

We also observe that the vertical axis of *Idocrase* is about half that of Tungstate of lime.

V. ZIRCON, $\bar{\dddot{\mathrm{Zr}}}\,\dddot{\mathrm{Si}}$—RUTILE, $\ddot{\mathrm{Ti}}$—TIN ORE, $\ddot{\mathrm{Sn}}$.

Rutile and Tin ore are recognized isomorphs; the basal angle of the octahedral fundamental forms are 84° 40′ for the former and 87° 5′ for the latter. In Zircon, the same angle is 84° 20′. The axes of rutile, tin ore and zircon are respectively 0·655, 0·6743, 0·6405.

VI. CINNABAR, Hg S—EUDIALYTE, $2\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}^2+\bar{\dddot{\mathrm{Zr}}}\,\dddot{\mathrm{Si}}^2$.

Cinnabar and Eudialyte are rhombohedral. In the former R : R = 71° 47′; in the latter, = 73° 40′.

VII. BORAX, $\dot{\mathrm{Na}}\,\dddot{\mathrm{B}}^2+10\dot{\mathrm{H}}$—PYROXENE, $\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}^2$—GLAUBER SALT, $(\dot{\mathrm{Na}}\,\dddot{\mathrm{S}}+10\dot{\mathrm{H}})$.

In Pyroxene	**M : M = 87° 6′;**	**0P : ∞P ∞ = 106° 6′**	**axes 0·2867 : 1 : 0·9506**
In Borax	**" 87°**	**" 106° 35′**	**0·2978 : 1 : 0·9489**

Glauber salt is also near pyroxene. It has **M : M** = 86° 31′ and **0P : ∞ P ∞** = 104° 41′.

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occurrence being selected. They express only a relation of length, and constitute a measure for determining or designating all the other occurring forms. The form assumed for Epsom salt, would be the form ½P of Chrysolite. And if the planes ½P in Epsom salt were taken for the fundamental form then the axes would be the same (nearly) as for Chrysolite.

VIII. ANATASE, $\ddot{\mathrm{T}}\mathrm{i}$—HORN QUICKSILVER, Hg Cl.

A pyramid in Horn quicksilver has the basal angle 136°; and the corresponding angle of anatase is 136° 22′.

IX. SULPHUR, S, and SCORODITE, $\ddot{\bar{\mathrm{F}}}\mathrm{e}\ \dddot{\bar{\mathrm{A}}}\mathrm{s}+4\dot{\bar{\mathrm{H}}}$.

The axes of sulphur are 1·9043 : 1 : 0·8108; and those of Scorodite 0·9539 : 1 : 0·8527. The vertical axis of sulphur is hence double that of Scorodite (2 × 0·9539 = 1·9078), while the other axes are nearly equal. (The planes of the vertical rhombic prism common on crystals of scorodite, belong to the form $\infty\breve{P}2$.)

X. CELESTINE, $\dot{\mathrm{S}}\mathrm{r}\ \dddot{\mathrm{S}}$—WHITE IRON PYRITES, $\mathrm{Fe\ S^2}$—GRAPHIC TELLURIUM, $\mathrm{Ag\ Te+2Au\ Te^3}$.

The angle M : M of Celestine is 104°; of White Iron Pyrites 106° 2′; a brachydiagonal prism of the former has the side angle 103° 58′; of the latter 99° 58′. Graphic Tellurium has M : M = 107° 44′; a macrodiagonal prism in Celestine is 101° 24′, in Graphic Tellurium 103°.

XI. CHROMATE OF LEAD, $\dot{\mathrm{P}}\mathrm{b}\ \dddot{\mathrm{C}}\mathrm{r}$—MONAZITE, $(\dot{\mathrm{C}}\mathrm{e}, \dot{\mathrm{T}}\mathrm{h}, \dot{\mathrm{L}}\mathrm{a})^3\ \ddot{\bar{\mathrm{P}}}$.

The forms are monoclinic. In Chromate of Lead, M : M = 93° 40′ and P : M = 99° 11′. In Monazite, M : M = 93° 10′ and P : M = 100° – 100° 25′. The forms of the crystals are similar in the occurring secondary planes.—Compare figure 2 of Chromate of Lead in the author's Mineralogy* with 2 of Monazite in the same work;† the general form is similar; and the planes M, ē, ĕ, ă, ĕ, *a*, *a*′, (∞P, +P, – P, – P∞, ∞P′∞, P′∞, 2P′∞) are the same in the two. ē : ē in the former is 119°, in the latter 119° 22′; ĕ : ĕ in the former is 107° 40′, in the latter 106° 36′.

XII. BERYL, $\dot{\bar{\mathrm{B}}}\mathrm{e}\ \dddot{\mathrm{S}}\mathrm{i}^4+2\dddot{\bar{\mathrm{A}}}\mathrm{l}\ \dddot{\mathrm{S}}\mathrm{i}^2$, or $\dot{\mathrm{B}}\mathrm{e}^3\ \dddot{\mathrm{S}}\mathrm{i}^2+\dddot{\bar{\mathrm{A}}}\mathrm{l}\ \dddot{\mathrm{S}}\mathrm{i}^2$—NEPHELINE, $\dot{\mathrm{R}}^2\ \dddot{\mathrm{S}}\mathrm{i}+2\dddot{\bar{\mathrm{A}}}\mathrm{l}\ \dddot{\mathrm{S}}\mathrm{i}$.

In Nepheline, P on two planes on the basal edges is 134° 3′ and 154° 27′; in beryl, the corresponding angles are 130° 59′ and 150° 6′. The vertical axis of nepheline is 0·4629, of beryl 0·4993. These species are only approximately isomorphous.

The axis of *quartz* is a little more than double that of beryl, it being 1·0996 and 2 × 0·4993 = 0·9996.

We mention also, without particular remark, some of the admitted cases of isomorphism, among species that are alike in general constitution but different in atomic proportions.

1. Pyroxene, Acmite, Hornblende and varieties.
2. Scapolite, Meionite, Wernerite, Dipyre, Gehlenite.
3. Talc, containing magnesia and silica in different proportions.

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* Fig. 74, pl. x, Mohs's Naturg. des Min., ii.

† Also Am. Jour. Sci., xxxiii, p. 71, fig. 1, but with different lettering; and the same figure copied in Dufrenoy's Mineralogie, vol. iv, pl. 223, fig. 476.

4. Epidote, Zoisite, Orthite.
5. The Feldspar family.
6. Bucholzite, Kyanite.
7. Different groups among the monometric or tesseral species.

It is not my object in this place to mention the cases of isomorphism that conform to the ordinary law on this subject. With this brief enumeration of some of the groups, I proceed to the consideration of the atomic volumes of the species. The atomic volume is obtained by dividing the atomic weight by the specific gravity.

I present first an example of the atomic volumes of a group of acknowledged isomorphous minerals, as a measure of the degree of discrepancy to be expected. The carbonates of lime, lime and magnesia, manganese, iron, magnesia, and zinc, increase in the angle R : R from 105° 5′ to 107° 40′, and the atomic volumes, as determined by Kopp, are respectively as follows:

231·20, 202·36, 202·29, 188·50, 181·25, 175·33.

The range of numbers is quite wide in this series, amounting to ¼ the larger number, and exceeds what usually occurs among isomorphous species. Yet the extent of the variation, here shown to be possible, should be kept in mind, or we may be led into error by expecting too close coincidences.

In the following calculations, either the mean specific gravity, as nearly as it could be determined, has been taken, or the specific gravity corresponding to some analysis selected for comparison. The atomic weights used are from the table on pages 218, 219, of this volume. By way of distinction as well as brevity in the following enunciations, we number the statement of the aggregate atomic volume by A; that in which the aggregate atomic volume is divided by the number of atoms of bases and acid, by B; and that of the same divided by the number of atoms of the elements, by C.

I. *Chrysoberyl, Chrysolite, Serpentine, Villarsite, Picrosmine, Epsom Salt.*

1. Chrysoberyl.

1 $\dot{\text{B}}\text{e}$=158·084 *b.* atoms of acid and base, 2. *c.* atoms of elements, 7.
1 $\bar{\text{A}}\text{l}$ 641·80 A. 799·884÷3·7 (sp. gr.)=216·18

a. At. weight, 799·884 B. 216·18÷2=108·9 C. 216·18÷7=30·9

With the old atomic weight of Glucinum, making glucina 962·52, we have the formula $\bar{\text{B}}\text{e}\ \bar{\text{A}}\text{l}^6$, which gives

1 $\bar{\text{B}}\text{e}$ 962·52 *b.* atoms of acid and base, 7. *c.* atoms of elements, 35.
6 $\bar{\text{A}}\text{l}$ 3850·8 A. 4813·32÷3·7 (sp. gr.)=1300·9

a. At. volume, 4813·32 B. 1300·9÷7=185·8 C. 1300·9÷35=37·16

The formula $\bar{\text{A}}\text{l}^4\ \dddot{\text{S}}\text{i}+2\bar{\text{B}}\text{e}\ \bar{\text{A}}\text{l}^4$, which differs from the last only in including an atom of silica for 12 of alumina, gives the value of C equal to 37·29.

With von Kobell's atomic weight, which is for glucina one third the last mentioned, (320·98 for glucina), chrysoberyl is $\dot{\text{B}}\text{e}\ \bar{\text{A}}\text{l}^2$, and the atomic weight is 1604·58; A=433·7; B=144·6; C=36·14.

2. Chrysolite.
1 $\dddot{Si}$=577·31 *b.* atoms of acid and bases, 4. *c.* atoms of elements, 10.
$2\frac{8}{11}\dot{Mg}$ 694·1 A. 1394·18÷3·35 (sp. gr.)=416
$\frac{3}{11}\dot{Fe}$ 122·72 B. 416÷4=104 C. 416÷10=41·6
a. At. weight, 1394·13

3. Serpentine.
4 $\dddot{Si}$= 2309·24 *b.* atoms of acid and bases, 19. *c.* atoms of elements, 46.
9 $\dot{Mg}$ 2290·50 A. 5274·62÷2·55 (sp. gr.)=2068·5
6 $\dot{H}$ 674·88 B. 2068·5÷19=109 C. 2068·5÷46=44·9
a. At. weight, 5274·62

4. Villarsite.
4 $\dddot{Si}$= 2309·24 *b.* atoms of acid and bases, 19. *c.* atoms of elements, 46.
12 $\dot{Mg}$ 3054·0 A. 5700·68÷2·975 (sp. gr.)=1916·3
3 $\dot{H}$ 337·44 B. 1916·3÷19=100·86 C. 1916·3÷46=41·65
a. At. weight, 5700·68

5. Picrosmine.
4 $\dddot{Si}$= 2309·24 *b.* atoms of acid and bases, 13. *c.* atoms of elements, 34.
6 $\dot{Mg}$ 1527·0 A. 4173·68÷2·63 (sp. gr.)=1587
3 $\dot{H}$ 337·44 B. 1587÷13=122 C. 1587÷34=46·68
a. At. weight, 4173·68

6. Epsom Salt.
1 $\dddot{S}$= 500· *b.* atoms of acid and bases, 9. *c.* atoms of elements, 20.
1 $\dot{Mg}$ 254·5 A. 1541·86÷1·75 (sp. gr.)=881
7 $\dot{H}$ 787·36 B. 881÷9=98 C. 881÷20=44
a. At. weight, 1541·86

The result shows that these different substances have for atomic volume C, Chrysolite 41·6, Villarsite 41·65, Epsom salt 44, Serpentine 44·9, Picrosmine 46·7; and for Chrysoberyl 30·9, (adopting Awdejew's atomic weight,) which is to that of Chrysolite as 2 : 3; or with the old atomic weight 37·15, a little below that of Chrysolite. The B results are also nearly uniform; they are for Chrysolite 104, for Villarsite 100·86, Epsom salt 98, Serpentine 109, Picrosmine 122, Chrysoberyl 108·9, or with the old atomic weight, 185·77. It would seem from the result with Epsom salt, that it is more correct to consider the hydrogen in water as a single rather than a double atom.

We pass on with the other examples without special remark, the results being tabulated on a subsequent page.

II. *Quartz, Chabazite.*

1. Quartz.
$\dddot{Si}$= 577·31 A. 577·31÷2·65 (sp. gr.)=218. C. 218÷4=54·5.

2. Chabazite.
8 $\dddot{Si}$=4618·48 *b.* atoms of acid and bases, 32. *c.* atoms of elements, 89.
3 $\dddot{Al}$ 1925·4 A. 9622·99÷2·1 (sp. gr.)=4582·4
3 $\dot{Ca}$ 1054·47 B. 4582·4÷32=143. C. 4582·4÷89=51·5
18 $\dot{H}$ 2024·64
a. At. weight, 9622·99

III. *Corundum, Specular Iron, Arsenic, Phenacite.*

1. Corundum. $\ddot{\bar{\mathrm{A}}}\mathrm{l}$=641·8÷3·97 (sp. gr.)=161·7 C. 161·7÷5=32·3
2. Specular Iron. $\bar{\mathrm{F}}\mathrm{e}$=1000÷5·212 (sp. gr.)=192 C. 192÷5=38·4
3. Arsenic. As, 940·08÷5·75 (sp. gr.)=163, which equals 5×32·6. The specific gravity 5·88 gives for atomic volume 160.

4. Phenacite.

1 $\dddot{\mathrm{Si}}$= 577·31 *b.* atoms of acid and base, 4. *c.* atoms of elements, 10.
3 $\dot{\mathrm{Be}}$ 474·25 A. 1051·56÷2·97 (sp. gr.)—354

a. At. weight, 1051·56 B. 354÷4—88·5 C. 354÷10—35·4

With the old atomic weight for glucinum, Phenacite has the formula $\bar{\mathrm{B}}\mathrm{e}\,\dddot{\mathrm{Si}}^2$, which gives

A. 2117·14÷2·97 (sp. gr.)—713 C. 713÷13—55, which is 1½ times that of specular iron.

Antimony, Bismuth, Tellurium and Osmium are isomorphous with Arsenic.

5. Antimony, Sb, 1612·8÷6·702 (sp. gr.)—240·65
6. Bismuth, Bi, 1330·4÷9·8 (sp. gr.)—135·75
7. Tellurium, Te, 802·÷6·2 (sp. gr.)—129·36
8. Osmium, Os, 1242·6÷10 (sp. gr.)—124·26

The atomic volume of Corundum is to that of Arsenic as 1 : 5, to that of Antimony nearly as 1 : 8, and to that of each of the other metals following nearly as 1 : 4. The discrepancies, if considered such, it will be observed are among *acknowledged isomorphs;* and a more exact knowledge of the atomic weight may remove them.

IV. *Scheelite, Tungstate of Lead, Fergusonite.*

1. Scheelite.

1 $\dddot{\mathrm{W}}$—1488·4 *b.* atoms of acid and base, 2. *c.* atoms of elements, 6.
1 $\dot{\mathrm{Ca}}$ 351·5 A. 1839·9÷6·1 (sp. gr.)—301·6

a. At. weight, 1839·9 B. 301·6÷2—150·8 C. 301·6÷6—50·3

2. Tungstate of Lead.

1 $\dddot{\mathrm{W}}$—1488·4 A. 2882·9÷8·1 (sp. gr.)—355·9
1 $\dot{\mathrm{Pb}}$ 1394·5 B. 355·9÷2—177·9 C. 355·9÷6—59·3

a. At. weight, 2882·9

3. Fergusonite. *b.* atoms of acid and base, 7. *c.* atoms of elements, 7.
1 $\bar{\mathrm{T}}\mathrm{a}$ 2596·8 A. 5611·8÷5·8 (sp. gr.)—967·5.
6 $\dot{\mathrm{Y}}$ 3015·0 B. 967·5÷7—138·2 C. 967·5÷17—57·0.

a. At. weight, 5611·8

We have introduced here the acknowledged isomorph of Scheelite, Tungstate of Lead, in order to afford a more satisfactory comparison with Fergusonite.

V. *Zircon, Rutile, Tin Ore* (acknowledged isomorph of rutile).

1. Zircon.

1 $\dddot{\mathrm{Si}}$— 577·31 *b.* atoms of acid and base, 2. *c.* atoms of elements, 9.
1 $\bar{\mathrm{Z}}\mathrm{r}$ 1139·50 A. 1716·81÷4·636 (sp. gr.)—370·3

a. At. weight, 1716·81 B. 370·3÷2—185·15 C. 370·3÷9—41·15.

2. Rutile. $\ddot{\mathrm{Ti}}$—514·7÷4·21 (sp. gr.)—122·3. C. 122·3÷3—40·7
3. Tin Ore. $\ddot{\mathrm{Sn}}$—935·3÷6·96 (sp. gr.)—134·4. C. 134·4÷3—44·8

VI. *Cinnabar, Eudialyte.*

1. Cinnabar. Hg S=1450 1450÷8·1 (sp. gr.)=180. C. 180÷2=90.

2. Eudialyte.

6	$\dddot{Si}$	3463·86	*b.* atoms of acid and bases, 13.	*c.* atoms of elements, 41.
1	$\dddot{\bar{Zr}}$	1139·50	A. 6909·33÷2·9 (sp. gr.)=2382	
1	$\dot{Fe}$	450·00	B. 2382÷13=183·2	C. 2382÷41=58·1
2½	$\dot{Ca}$	878·72		
2½	$\dot{Na}$	977·25		

a. At. weight, 6909·33

The relation of 58 : 90, is nearly as 2 : 3 (60 : 90.); of 180 :183·2=1 : 1

VII. *Borax, Glauber Salt, Pyroxene.*

1. Borax.

2	$\dddot{B}$	= 872·4	*b.* atoms of acid and bases, 13.	*a.* atoms of elements, 30.
1	$\dot{Na}$	390·9	A. 2388·1÷1·716=1391·6	
10	$\dot{H}$	1124·8	B. 1391·6÷13=107·0	C. 1391·6÷30=46·38.

a. At. weight, 2388·1

2. Glauber Salt.

1	$\dddot{S}$	= 500·	*b.* atoms of acid and bases, 12.	*c.* atoms of elements, 26.
1	$\dot{Na}$	390·9	A. 2015·7÷1·562 (sp. gr.)=1290·5.	
10	$\dot{H}$	1124·8	B. 1290·5÷12=107·54	C. 1290·5÷26=49·6

a. At. weight, 2015·7

3. Pyroxene.—1st. var. $(\frac{1}{2}\dot{Ca}+\frac{1}{2}\dot{Mg})^3\,\dddot{Si}^2$. Color white.

2	$\dddot{Si}$	=1154·62	*b.* atoms of acid and bases, 5.	*a.* atoms of elements, 14.
1½	$\dot{Ca}$	527·23	A. 2063·60÷3·24 (sp. gr.)=637	
1½	$\dot{Mg}$	381·75	B. 637÷5=127·4	C. 637÷14=45·5

a. At. weight, 2063·60

4. Pyroxene.—2nd. var. $(\frac{1}{2}\dot{Ca}+\frac{1}{3}\dot{Mg}+\frac{1}{6}\dot{Fe})^3\,\dddot{Si}^2$. Color green or black.

2	$\dddot{Si}$	=1154·62		
1½	$\dot{Ca}$	527·23	A. 2161·35÷3·35 (sp. gr.)=645·2	
1	$\dot{Mg}$	254·50	B. 645·2÷5=129	C. 645·2÷14=46·1
½	$\dot{Fe}$	225·		

a. At. weight, 2161·35

5. Pyroxene.—3d var. $(\frac{1}{2}\dot{Ca}+\frac{1}{2}\dot{Fe})^3\,\dddot{Si}^2$. Hedenbergite.

2	$\dddot{Si}$	=1154·62		
1½	$\dot{Ca}$	527·23	A. 2356·85÷3·5 (sp. gr.)=673·4	
1½	$\dot{Fe}$	675·00	B. 673·4÷5=134·7	C. 673·4÷14=48·1

a. At. weight, 2356·85

6. Pyroxene—var. *Hudsonite.* A recent analysis in the Yale Laboratory, New Haven, by Mr. W. H. Brewer,* gives nearly the results of Beck for this mineral, but makes

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* Mr. Brewer obtained the following for the composition of the Hudsonite; we add also Beck's results:—

	I.	Oxygen.		II.	III.	Beck.
Silica,	36·94	19·13	24·17	36·06	36·76	37·90
Alumina,	11·22	5·04		10·47	....	12·70
Peroxyd of iron,	*trace*	....		*trace*	....	....
Protoxyd of iron,	36·03	8·00		36·57	....	36·80
" manganese,	2·24	0·50	12·12	1·10	....	$\dot{Mg}$ 1·92
Lime,	12·71	3·62		....	....	11·40
	99·14					100·72

Beck uses the term *oxyd of iron;* but we infer from his accompanying remarks that he meant protoxyd. G.=3·43—3·46, Brewer; 3·5, Beck.

the iron protoxyd, with but a trace of peroxyd. It affords very closely the formula $\dot{\text{R}}^3\,(\dddot{\text{Si}}, \dddot{\bar{\text{Al}}})^2$, or more precisely $\left(\frac{8}{12}\dot{\text{Fe}}+\frac{0·5}{12}\dot{\text{Mn}}+\frac{3·5}{12}\dot{\text{Ca}}\right)^3\left(\frac{6·33}{8}\dddot{\text{Si}}+\frac{1·66}{8}\dddot{\bar{\text{Al}}}\right)^2$. Multiplying by 4 throughout, the relation becomes $6\tfrac{1}{3}\dddot{\text{Si}}+1\tfrac{2}{3}\dddot{\bar{\text{Al}}}+8\dot{\text{Fe}}+\tfrac{1}{2}\dot{\text{Mn}}+3\tfrac{1}{2}\dot{\text{Ca}}$, which we here adopt, without farther reducing it, as the result will be the same.

$6\tfrac{1}{3}\ \dddot{\text{Si}}$ =3656·3   *b.* atoms of acids and bases, 20.   *c.* atoms of elements, 57⅔.
$1\tfrac{2}{3}\ \dddot{\bar{\text{Al}}}$ 1069·6   A. 9778·4÷3·463 (mean sp. gr.)=2824, and 2824÷4=706
$8\ \dot{\text{Fe}}$ 3600·0   B. 2824÷20=141·2   C. 2824÷57⅔=48·9
$\tfrac{1}{2}\ \dot{\text{Mn}}$ 222·3
$3\tfrac{1}{2}\ \dot{\text{Ca}}$ 1230·2
a. At. weight, 9778·4

7. Pyroxene—var. $\dot{\text{Fe}}^3\,\dddot{\text{Si}}^2$. Asbestiform, analyzed by Grüner, (Comp. Rend. xxiv, 794.)
$3\ \dot{\text{Fe}}$ =1350·   *b.* atoms of acid and bases, 5.   *c.* atoms of elements, 14.
$2\ \dddot{\text{Si}}$ 1154·62   A. 2504·62÷3·712 (sp. gr.) =674·7
a. At. weight, 2504·62   B. 674·7÷5=135   C. 674·7÷14=48·2

8. Pyroxene—var. $\dot{\text{Mn}}^3\,\dddot{\text{Si}}^2$, Manganese Spar.
$3\ \dot{\text{Mn}}$ =1334·1   *b.* atoms of acid and base, 5.   *c.* atoms of elements, 14.
$2\ \dddot{\text{Si}}$ 1154·62   A. 2488·72÷3·634 (sp. gr.) =684·8
a. At. weight, 2488·72   B. 684·8÷5=136·9   C. 684·8÷14=48·9

VIII. *Anatase, Horn Quicksilver.*

1. Anatase. $\ddot{\text{Ti}}$ 514·7÷3·84 (sp. gr.) =134·0   C. 134·0÷3=44·66
2. Horn Quicksilver, Hg Cl, 1693·3÷6·48 (sp. gr.) =261·3   C. 261·3÷2=130·62

130·62 : 44·66, nearly as 3 : 1 ; and 130·62 : 134·0 = (nearly) 1 : 1.

IX. *Sulphur, Selenium* (acknowledged isomorph with Sulphur), *Scorodite.*

1. Sulphur.   S, 200÷2·033 (sp. gr.) =98·4
2. Selenium.   Se, 495·3÷4·3 (sp. gr.) =115
3. Scorodite.

$1\ \overset{\cdot\cdot\cdot\cdot\cdot}{\bar{\text{As}}}$ =1440·08   *b.* atoms of acid and bases, 6.   *c.* atoms of elements, 19.
$1\ \dddot{\bar{\text{Fe}}}$ 1000·00   A. 2890÷3·23 (sp. gr.) =894·73
$4\ \dot{\text{H}}$ 449·92   B. 894·73÷6=149·12   C. 894·73÷19=47·1
a. At. weight, 2890·00

47·1, is very nearly ½ the atomic volume of Sulphur; and 149 : 98·4=3 : 2

X. *Celestine, White Iron Pyrites, Graphic Tellurium.*

1. Celestine.

$1\ \dddot{\text{S}}$ = 500·   *b.* atoms of acid and base, 2.   *c.* atoms of elements, 6.
$1\ \dot{\text{Sr}}$ 647·3   A. 1147·3÷3·9 (sp. gr.) =294·2
a. At. weight, 1147·3   B. 294·2÷2=147·1   C. 294·2÷6=49·0

2. White Iron Pyrites.

Fe+2S=750.   A. 750÷4·76 (sp. gr.)=157·56   C. 157·56÷3=52·52

3. Graphic Tellurium.

7 Te =5612·6   *c.* atoms of elements, 10.
1 Ag   1350·   A. 9418·1÷8·28 (sp. gr.) =1137·5
2 Au   2455·5   C. 1137·5÷10=113·75
a. At. weight, 9418·1

The atomic volume C of graphic Tellurium is consequently double of that of White Iron Pyrites; the A relation is 7 : 1.

XI. *Monazite, Chromate of Lead.*

1. Monazite.

1 $\overset{\cdot\cdot\cdot\cdot\cdot}{P}$ = 892·3 *b.* atoms of acid and bases, 4. *c.* atoms of elements, 12.

2 $\dot{Ce}$ 1350·0 A. 3086·2÷5 (sp. gr.) =617·25

1 $\dot{Th}$ 843·9 B. 617·25÷4=154·3 C. 617·25÷12=51·44

a. At. weight, 3086·2 Marignac's at. wt. of Cerium, gives for C, 52

2. Chromate of Lead.

1 $\dddot{Cr}$ = 628·4 *b.* atoms of acid and base, 2. *c.* atoms of elements, 6.

1 $\dot{Pb}$ 1394·5 A. 2022·9÷6·06 (sp. gr.) =333·8

a. At. weights, 2022·9 B. 333·8÷2=166·9 C. 333·8÷6=55·6

There is some uncertainty as to Monazite, as the exact proportions of its bases are not accurately known.

XII. *Beryl, Nepheline.*

1. Beryl—using the old atomic weight:—

8 $\dddot{Si}$ =4618·48 *b.* atoms of acid and bases, 11. *c.* atoms of elements, 47.

1 $\dddot{\bar{Be}}$ 962·52 A. 6864·6÷2·732 (sp. gr.) =2512·7

2 $\dddot{\bar{Al}}$ 1283·60 B. 2512·7÷11=228·4 C. 2512·7÷47=53·46

a. At. weight, 6864·60 Awdejew's atomic weight gives for C, 46·44.

2. Nepheline.

3 $\dddot{Si}$ =1731·93 *b.* atoms of acid and bases, 7. *c.* atoms of elements, 26.

2 $\dddot{\bar{Al}}$ 1283·6 A. 3830·32÷2·6 (sp. gr.) =1473·2

1⅚ $\dot{Na}$ 716·65 B. 1473·2÷7=210·5 C. 1473·2÷26=56·66

⅙ $\dot{K}$ 98·14

a. At. weight, 3830·32

XIII. *Pyroxene*, $\dot{R}^3\,\dddot{Si}^2$—*Acmite*, $\dot{Na}\,\dddot{Si}+\dddot{\bar{Fe}}\,\dddot{Si}^2$—*Hornblende*, $\dot{R}^4\,\dddot{Si}^3$.

Acmite, as is well known, has the crystalline form of Pyroxene, although different in composition. Hornblende is peculiar in its cleavage and prevalent forms; yet as Rose has shown, its crystals have the same fundamental form as those of Pyroxene.

1. Pyroxene. As above deduced, A=638·77 – 706; B=127·55–141·2; C=46·1–48·9

2. Acmite.

3 $\dddot{Si}$ = 1731·93 *b.* atoms of acid and bases, 5. *c.* atoms of elements, 19.

1 $\dddot{\bar{Fe}}$ 1000·00 A. 3122·83÷3·4 (sp. gr.) =918·5

1 $\dot{Na}$ 390·9 B. 918·5÷5=183·7 C. 918·5÷19=48·34

a. At. weight, 3122·83

3. Hornblende.

3 $\dddot{Si}$ = 1731·93 *b.* atoms of acid and bases, 7. *c.* atoms of elements, 20.

3 $\dot{Mg}$ 763·5 A. 2846·92÷2·93 (sp. gr.) =971·6

1 $\dot{Ca}$ 351·49 B. 971·6÷7=138·8 C. 971·6÷20=48·58

a. At. weight, 2846·92

4. Hornblende, aluminous varieties.

a. Var. From Wolfsberg in Bohemia, analysed by Göschen.—The analysis corresponds to the ratio 2½$\dddot{\bar{Al}}$+1½$\dddot{\bar{Fe}}$+7 $\dddot{Si}$+4 $\dot{Ca}$+5 $\dot{Mg}$. We attempt no formula.

7 $\dddot{Si}$ =4041·17 *b.* atoms of bases and acids, 20. *c.* atoms of elements, 66.

2½ $\dddot{\bar{Al}}$ 1604·5 A. 9824·13÷3·15 (sp. gr.) =3119

1½ $\dddot{\bar{Fe}}$ 1500·0 B. 3119÷20=155·95 C. 3119÷66=47·25

4 $\dot{Ca}$ 1405·96

5 $\dot{Mg}$ 1272·5 If sp. gr.=3·167, then C=47·0

a. At. weight, 9824·13

b. Var. Carinthine. Analysis by Clausbruch (Pogg., lviii, 168), corresponding to $8\,\dddot{\mathrm{Si}}+1\tfrac{1}{3}\,\overline{\dddot{\mathrm{Al}}}+2\tfrac{6}{7}\,\dot{\mathrm{Ca}}+7\tfrac{1}{7}\,\dot{\mathrm{Mg}}+4\,\dot{\mathrm{Fe}}$.

$8\ \dddot{\mathrm{Si}} = 4618{\cdot}48$ *b.* atoms of acid and bases, $23\tfrac{1}{3}$. *c.* atoms of elements, $66\tfrac{2}{3}$.
$1\tfrac{1}{3}\ \overline{\dddot{\mathrm{Al}}}$ 855·73 A. $10096{\cdot}27 \div 3{\cdot}127$ (sp. gr.) $= 3229$
$4\ \dot{\mathrm{Fe}}$ 1800·00 B. $3229 \div 23\tfrac{1}{3} = 138{\cdot}4$ C. $3229 \div 66\tfrac{2}{3} = 48{\cdot}43$
$2\tfrac{6}{7}\ \dot{\mathrm{Ca}}$ 1004·26
$7\tfrac{1}{7}\ \dot{\mathrm{Mg}}$ 1817·80

a. At. weight, 10096·27

c. Grammatite of Aker, Bonsdorff. The analysis gives $8{\cdot}17\,\dddot{\mathrm{Si}}+2{\cdot}17\,\overline{\dddot{\mathrm{Al}}}+3{\cdot}6\,\dot{\mathrm{Ca}}+8{\cdot}6\,\dot{\mathrm{Mg}}+0{\cdot}6\,\dot{\mathrm{Fe}}$. As above, we take the analysis as it is, without attempting to reduce it to the limits of a formula.

$8{\cdot}17\ \dddot{\mathrm{Si}} = 4716{\cdot}6$ *b.* atoms of acid and bases, 23·13. *c.* atoms of elements, 69·1.
$2{\cdot}17\ \overline{\dddot{\mathrm{Al}}}$ 1392·7 A. $9833{\cdot}4 \div 2{\cdot}95$ (sp. gr.) $= 3333{\cdot}3$
$3{\cdot}6\ \dot{\mathrm{Ca}}$ 1265·4 B. $3333{\cdot}3 \div 23{\cdot}14 = 144$ C. $3333{\cdot}3 \div 69{\cdot}1 = 48{\cdot}24$
$8{\cdot}6\ \dot{\mathrm{Mg}}$ 2188·7
$0{\cdot}6\ \dot{\mathrm{Fe}}$ 270·0

a. At. weight, 9833·4

XIV. *Scapolite,* $(\dot{\mathrm{Ca}}, \dot{\mathrm{Na}})^3\,\dddot{\mathrm{Si}}^2+2\overline{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}$—*Meionite,* $\dot{\mathrm{Ca}}^3\,\dddot{\mathrm{Si}}+2\overline{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}$—*Wernerite,* $\dot{\mathrm{Ca}}^3\,\dddot{\mathrm{Si}}+3\overline{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}$—*Dipyre,* $4(\dot{\mathrm{Ca}}, \dot{\mathrm{Na}})\,\dddot{\mathrm{Si}}+3\overline{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}$.

These several compounds crystallize alike.

1. Scapolite.

$4\ \dddot{\mathrm{Si}} = 2309{\cdot}24$ *b.* atoms of acid and bases, 9. *c.* atoms of elements, 32.
$2\ \overline{\dddot{\mathrm{Al}}}$ 1283·6 A. $4686{\cdot}72 \div 2{\cdot}71$ (sp. gr.) $= 1729{\cdot}4$
$1\ \dot{\mathrm{Na}}$ 390·9 B. $1729{\cdot}4 \div 9 = 192{\cdot}1$ C. $1729{\cdot}4 \div 32 = 54$
$2\ \dot{\mathrm{Ca}}$ 702·98

a. At. weight, 4686·72

2. Meionite.

$3\ \dddot{\mathrm{Si}} = 1731{\cdot}93$ *b.* atoms of acid and bases, 8. *c.* atoms of elements, 28.
$2\ \overline{\dddot{\mathrm{Al}}}$ 1283·6 A. $4070 \div 2{\cdot}612$ (sp. gr.) $= 1558{\cdot}2$
$3\ \dot{\mathrm{Ca}}$ 1054·47 B. $1558{\cdot}2 \div 8 = 194{\cdot}8$ C. $1558{\cdot}2 \div 28 = 55{\cdot}65$

a. At. weight, 4070·00

3. Wernerite—From Tunaberg and Ersby, as analysed by Walmstedt and Nordenskiöld.

$4\ \dddot{\mathrm{Si}} = 2309{\cdot}24$ *b.* atoms of acid and bases, 10. *c.* atoms of elements, 37.
$3\ \overline{\dddot{\mathrm{Al}}}$ 1925·4 A. $5289{\cdot}11 \div 2{\cdot}77$ (sp. gr.) $= 1909$
$3\ \dot{\mathrm{Ca}}$ 1054·47 B. $1909 \div 10 = 190{\cdot}9$ C. $1909 \div 37 = 51{\cdot}6$

a. At. weight, 5289·11

4. Dipyre.

$7\ \dddot{\mathrm{Si}} = 4041{\cdot}17$ *b.* atoms of acid and bases, 14. *c.* atoms of elements, 51.
$3\ \overline{\dddot{\mathrm{Al}}}$ 1925·4 A. $7451{\cdot}35 \div 2{\cdot}646$ (sp. gr.) $= 2816$
$2\ \dot{\mathrm{Na}}$ 781·8 B. $2816 \div 14 = 201{\cdot}1$ C. $2816 \div 51 = 55{\cdot}21$
$2\ \dot{\mathrm{Ca}}$ 702·98

a. At. weight, 7451·35

5. Barsowite.—$(\dot{\mathrm{Ca}}, \dot{\mathrm{Mg}})^3\,\dddot{\mathrm{Si}}^2+3\overline{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}$. This scapolite-like mineral has A = 2133; B = 194; C = 52.

6. Wernerite—Wolff's analysis of a Pargas variety corresponds very closely with $\dot{\mathrm{Ca}}^2\dddot{\mathrm{Si}}+2\bar{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}$ (although referred to the above Wernerite formula by Rammelsberg.)

3 $\dddot{\mathrm{Si}}$	=1731·93	*b.* atoms of acid and bases, 7.	*c.* atoms of elements, 26.
2 $\bar{\dddot{\mathrm{Al}}}$	1283·6	A. 3718·51÷2·712 (sp. gr.) =1371·1	
2 $\dot{\mathrm{Ca}}$	702·98	B. 1371·1÷7=196	C. 1371·1÷26=52·7
a. At. weight,	3718·51		

Idocrase has its vertical axis to that of Scapolite as 5 : 4, and Zircon to that of Idocrase as 6 : 5. For comparison we here insert the atomic volume of Idocrase.

2 $\dddot{\mathrm{Si}}$	=1154·62	*b.* atoms of acid and bases, 6.	*c.* atoms of elements, 19.
1 $\bar{\dddot{\mathrm{Al}}}$	641·8	A. 2883·72÷3·4 (sp. gr.)=848·16	
2⅔ $\dot{\mathrm{Ca}}$	937·3	B. 848·16÷6=141·36	848·16÷19=44·64
⅓ $\dot{\mathrm{Fe}}$	150·		
a. At. weight,	2883·72		

The atomic volumes of Scapolite, Idocrase and Zircon, are as 54 : 44·64 : 41·05.

XV. *Talc.*—Different varieties, $\dot{\mathrm{Mg}}^3\,\dddot{\mathrm{Si}}^4$, $\dot{\mathrm{Mg}}^4\,\dddot{\mathrm{Si}}^5$, $\dot{\mathrm{Mg}}\,\dddot{\mathrm{Si}}$.

1.	4 $\dddot{\mathrm{Si}}$	=2309·24	*b.* atoms of acid and base, 7.	*c.* atoms of elements, 22.
	3 $\dot{\mathrm{Mg}}$	763·5	A. 3072·74÷2·7 (sp. gr.) =1138	
			B. 1138÷7=162·57	C. 1138÷22=51·73
a. At. weight,		3072·74		
2.	5 $\dddot{\mathrm{Si}}$	=2886·55	*b.* atoms of acid and base, 9.	*c.* atoms of elements, 28.
	4 $\dot{\mathrm{Mg}}$	1018·0	A. 3904·55÷2·7 (sp. gr.) =1446	
			B. 1446÷9=160·7	C. 1446÷28=51·64
a. At. weight,		3904·55		
3.	1 $\dddot{\mathrm{Si}}$	= 577·31	*b.* atoms of acid and base, 2.	*c.* atoms of elements, 6.
	1 $\dot{\mathrm{Mg}}$	254·5	A. 831·81÷2·7 (sp. gr.) =308·1	
			B. 308·1÷2=154	C. 308·1÷6=51·35
a. At. weight,		831·81		

XVI. *Epidote* $\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}+2\bar{\dddot{\mathrm{R}}}\,\dddot{\mathrm{Si}}$.—*Orthite* $2(\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}+\bar{\dddot{\mathrm{R}}}\,\dddot{\mathrm{Si}})+\dot{\mathrm{H}}$ of the Ural; $\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}+\bar{\dddot{\mathrm{R}}}\,\dddot{\mathrm{Si}}+\dot{\mathrm{H}}$, of Hitteroe.

Orthite has been shown by Kokscharov (Min. Ges. St. Petersb., 1847, p. 147, and this Journal [2], viii, 125), to have the crystallization of Epidote. M : T in Epidote =114° 25′; in Uralorthite 114° 55′ Kokscharov; in Cerine 116° Rose. The above formulas of Orthite are recent results by Rammelsberg, (Poggendorff's Annalen, lxxvi, 98, 1849.) This author also calculates the atomic volume corresponding to the specimens analyzed, and obtains for Epidote having the formula $(\dot{\mathrm{Ca}}^3\,\dddot{\mathrm{Si}})+2(\tfrac{2}{3}\bar{\dddot{\mathrm{Al}}}+\tfrac{1}{3}\bar{\dddot{\mathrm{Fe}}})\,\dddot{\mathrm{Si}}$, the atomic weight 4309·53, and 4309·53÷3·4 (sp. gr.)=1268.

For Orthite of the Urals (in which $6\dot{\mathrm{R}}=1{\cdot}2\,\dot{\mathrm{Fe}}+2{\cdot}4(\dot{\mathrm{Ce}},\dot{\mathrm{La}})+2{\cdot}4\,\dot{\mathrm{Ca}}$; and $2\bar{\dddot{\mathrm{R}}}=1{\cdot}5\,\bar{\dddot{\mathrm{Al}}}+0{\cdot}5\,\bar{\dddot{\mathrm{Fe}}}$), the atomic weight 6911·82; and 6911·82÷3·598=1921.

For the Orthite of Hitteroe, in which $3\dot{\mathrm{R}}=0{\cdot}6\,\dot{\mathrm{Fe}}+1{\cdot}2\,\dot{\mathrm{Ce}}+1{\cdot}2\,\dot{\mathrm{Ca}}$; and $\bar{\dddot{\mathrm{R}}}=0{\cdot}7\,\bar{\dddot{\mathrm{Al}}}+0{\cdot}3\,\bar{\dddot{\mathrm{Fe}}}$, the atomic weight 3513·72; and 3518·72÷3·459 (sp. gr.) =1017.

Rammelsberg thence observes that the atomic volumes of these minerals are as 1 : 1·5 : 0·8, "or perhaps" as 4 : 6 : 3.

If, however, as heretofore, we divide the aggregate atomic volume obtained by Rammelsberg by the number of atoms of the elements, we obtain

1. For Epidote	1268÷28=45·285
2. For Orthite of the Urals	1921÷40=48·025
3. For the Orthite of Hitteroe	1017÷21=48·43

A close relation, exhibiting satisfactorily the intimate relations of the compounds. Dividing by the number of atoms of bases and acids, gives respectively 1268÷8=158·5, 1921÷13=147·7, 1017÷7=145·3.

4. We add another example—a *Zoisite* from Rothlaue analyzed by Rammelsberg, (Pogg., lxviii, 509.)

3 $\dddot{\mathrm{Si}}$ =1731·93 *b.* atoms of acid and bases, 8. *c.* atoms of elements, 28.
$1\frac{2}{3}$ $\dddot{\mathrm{Al}}$ 1069·7 A. 4189·43÷3·387 (sp. gr.) =1237
$\frac{1}{3}$ $\dddot{\mathrm{Fe}}$ 333·33 B. 1237÷8=154·6 C. 1237÷28=44·2
3 $\dot{\mathrm{Ca}}$ 1054·47

a. At. weight, 4189·43

Here 44·2 is but little below the determination for Epidote.

XVII. *The Feldspar Family.*—In Orthoclase and Albite, Ryacolite and Labradorite, Loxoclase and Oligoclase, we have three examples of dimorphism.

1. Orthoclase, $\dot{\mathrm{R}}\dddot{\mathrm{Si}}+\dddot{\mathrm{Al}}\dddot{\mathrm{Si}}^3$.—Form monoclinic.

4 $\dddot{\mathrm{Si}}$ =2309·24 *b.* atoms of acid and bases, 6. *c.* atoms of elements, 23.
1 $\dddot{\mathrm{Al}}$ 641·80 A. 3539·90÷2·55 (sp. gr.) =1388
1 $\dot{\mathrm{K}}$ 588·86 B. 1388÷6=231·3 C. 1388÷23=60·4

a. At. weight, 3539·90

2. Albite, $\dot{\mathrm{R}}\dddot{\mathrm{Si}}+\dddot{\mathrm{Al}}\dddot{\mathrm{Si}}^3$.—Form triclinic.

4 $\dddot{\mathrm{Si}}$ =2309·24 *b.* atoms of acid and bases, 6. *c.* atoms of elements, 23.
1 $\dddot{\mathrm{Al}}$ 641·80 A. 3341·94÷2·61 (sp. gr.) =1280·4
1 $\dot{\mathrm{Na}}$ 390·9 B. 1280·4÷6=213·4 C. 1280·4÷23=55·67

a. At. weight, 3341·94

3. Ryacolite, $\dot{\mathrm{R}}\dddot{\mathrm{Si}}+\dddot{\mathrm{Al}}\dddot{\mathrm{Si}}$.—Monoclinic.

2 $\dddot{\mathrm{Si}}$ =1154·62 *b.* atoms of acid and bases, 4. *c.* atoms of elements, 15.
1 $\dddot{\mathrm{Al}}$ 641·80 A. 2236·83÷2·58 (sp. gr.) =867·0
$\frac{3}{4}$ $\dot{\mathrm{Na}}$ 293·2 B. 867÷4=216·7 C. 867÷15=57·8
$\frac{1}{4}$ $\dot{\mathrm{K}}$ 147·21

a. At. weight, 2236·83

4. Labradorite, $\dot{\mathrm{R}}\dddot{\mathrm{Si}}+\dddot{\mathrm{Al}}\dddot{\mathrm{Si}}$.—Triclinic.

2 $\dddot{\mathrm{Si}}$ =1154·62 *b.* atoms of acid and bases, 4. *c.* atoms of elements, 15.
1 $\dddot{\mathrm{Al}}$ 641·80 A. 2147·91÷2·7 (sp. gr.) =795·5
1 $\dot{\mathrm{Ca}}$ 351·49 B. 795·5÷4=198·9 C. 795·5÷15=53·03

a. At. weight, 2147·91

5. Loxoclase, $\dot{\mathrm{R}}\dddot{\mathrm{Si}}+\dddot{\mathrm{Al}}\dddot{\mathrm{Si}}^2$.—Monoclinic.

3 $\dddot{\mathrm{Si}}$ =1731·93 *b.* atoms of acid and bases, 5. *c.* atoms of elements, 19.
1 $\dddot{\mathrm{Al}}$ 641·80 A. 2779·52÷2·615 (sp. gr.) =1063
$\frac{5}{8}$ $\dot{\mathrm{Na}}$ 244·31 B. 1063÷5=212·6 C. 1063÷19=56·0
$\frac{1}{8}$ $\dot{\mathrm{K}}$ 73·61
$\frac{1}{4}$ $\dot{\mathrm{Ca}}$ 87·87

a. At. weight, 2779·52

6. Oligoclase, $\dot{\mathrm{R}}\dddot{\mathrm{Si}}+\dddot{\mathrm{Al}}\dddot{\mathrm{Si}}^2$.—Triclinic.

3 $\dddot{\mathrm{Si}}$ =1731·93 *b.* atoms of acid and bases, 5. *c.* atoms of elements, 19.
1 $\dddot{\mathrm{Al}}$ 641·80 A. 2751·49÷2·65 (sp. gr.) =1038·3
$\frac{2}{3}$ $\dot{\mathrm{Na}}$ 260·66 B. 1038·3÷5=207·66 C. 1038·3÷19=54·647
$\frac{1}{3}$ $\dot{\mathrm{Ca}}$ 117·16

a. At. weight, 2751·49

We observe that the triclinic form in each of these three cases of dimorphism has the *highest specific gravity*, and the *lowest atomic weight*, and therefore the *lowest atomic volume.*

7. Anorthite, $\dot{R}^3\dddot{Si}+3\bar{\dddot{Al}}\dddot{Si}$.—Triclinic.

$4\ \dddot{Si}$ =2309·24 *b.* atoms of acid and bases, 10. *c.* atoms of elements, 37.
$3\ \bar{\dddot{Al}}$ 1925·40 A. 5289·11÷2·7=1959
$3\ \dot{Ca}$ 1054·47 B. 1959÷10=195·9 C. 1959÷37=52·95

a. At. weight, 5289·11

8. Baulite, $\dot{R}\dddot{Si}^2+\bar{\dddot{Al}}\dddot{Si}^6$.—Monoclinic.

$8\ \dddot{Si}$ =4618·48 *b.* atoms of acid and bases, 10. *c.* atoms of elements, 39.
$1\ \bar{\dddot{Al}}$ 641·80 A. 5750·16÷2·64 (sp. gr.) =2178·1
$\frac{1}{2}\ \dot{Na}$ 195·45 B. 2178·1÷10=217·81 C. 2178·1÷39=55·85
$\frac{1}{2}\ \dot{K}$ 294·43

a At. weight, 5750·16

9. Vosgite, $\dot{R}^3\dddot{Si}^2+3\bar{\dddot{Al}}\dddot{Si}$.—Triclinic.

$5\ \dddot{Si}$ =2886·55 *b.* atoms of acid and bases, 11. *c.* atoms of elements, 41.
$3\ \bar{\dddot{Al}}$ 1925·40 A. 5929·66÷2·737 (sp. gr.) =2166·5
$2\frac{2}{5}\ \dot{Ca}$ 843·58 B. 2166·5÷11=197 C. 2166·5÷41=52·84
$\frac{2}{5}\ \dot{Na}$ 156·36
$\frac{1}{5}\ \dot{K}$ 117·77

a. At. weight, 5929·66

10. Andesine, $\dot{R}^3\dddot{Si}^2+3\bar{\dddot{Al}}\dddot{Si}^2$.—Triclinic.

$8\ \dddot{Si}$ =4618·48 *b.* atoms of acid and bases, 14. *c.* atoms of elements, 53.
$3\ \bar{\dddot{Al}}$ 1925·40 A. 7776·15÷2·67 (sp. gr.) =2912·4
$1\frac{1}{2}\ \dot{Na}$ 586·35 B. 2912·4÷14=208 C. 2912·4÷53=55·0
$1\ \dot{Ca}$ 351·49
$\frac{1}{2}\ \dot{K}$ 294·43

a. At. weight, 7776·15

11. Leucite, $\dot{R}^3\dddot{Si}^2+3\bar{\dddot{Al}}\dddot{Si}^2$.—Monometric.

$8\ \dddot{Si}$ =4618·48 *b.* atoms of acid and bases, 14. *c.* atoms of elements, 53.
$3\ \bar{\dddot{Al}}$ 1925·40 A. 8310·46÷2·486=3343·15
$3\ \dot{K}$ 1766·58 B. 3343÷14=238·8 C. 3343÷53=63·08

a. At. weight, 8310·46

As Andesine and Leucite have essentially the same composition and the compound is therefore dimorphous, we here observe again that the triclinic form has the highest specific gravity and lowest atomic weight, and as a consequence, the lowest atomic volume.

XVIII. *Petalite*, $(\dot{Li}, \dot{Na})^3\dddot{Si}^4+4\bar{\dddot{Al}}\dddot{Si}^4$—*Spodumene*, $(\dot{Li}, \dot{Na})^3\dddot{Si}^4+4\bar{\dddot{Al}}\dddot{Si}^2$, —*Andalusite*, $\bar{\dddot{Al}}^3\dddot{Si}^2$.

1. Petalite.

$20\ \dddot{Si}$ =11546·20 *b.* atoms of acid and bases, 27. *c.* atoms of elements, 106.
$4\ \bar{\dddot{Al}}$ 2567·20 A. 14815·31÷2·44 (sp. gr.) =6071·8
$2\frac{1}{4}\ \dot{Li}$ 408·73 B. 6071·8÷27=224·96 C. 6071·8÷106=57·3
$\frac{3}{4}\ \dot{Na}$ 293·18

a. At. weight, 14815·31

2. Spodumene.

12 $\dddot{\text{Si}}$	=6927·72	*b.* atoms of acid and bases, 19.	*c.* atoms of elements, 74.
4 $\dddot{\bar{\text{A}}}\text{l}$	2567·20	A. 10196·83÷3·17=3216·7	
2¼ $\dot{\text{L}}\text{i}$	408·73	B. 3216·7÷19=169·3	C. 3216·7÷74=43·47
¾ $\dot{\text{N}}\text{a}$	293·18		
a. At. weight,	10196·83		

Petalite has the structure of a *feldspar*, although not conforming to the general rule for the feldspar family in having the oxygen of the peroxyds to that of the protoxyds as 3 : 1, but instead as 4 : 1. It also approaches Orthoclase in its atomic volume, B equalling 224·9 and C 57·31, while in Orthoclase B=231·3 and C=60·4. *Spodumene*, on the contrary, although a lithia species like petalite, and having also the above ratio 4 : 1, differs in its cleavage and in its crystalline form, and is also widely removed from the feldspars in its atomic volume.

3. Andalusite.

2 $\dddot{\text{Si}}$	=1154·62	*b.* atoms of acid and base, 5.	*c.* atoms of elements, 23.
3 $\dddot{\bar{\text{A}}}\text{l}$	1925·40	A. 3080·02÷3·2 (sp. gr.) =962·5	
a. At. volume,	3080·02	B. 962·5÷5=192·5	C. 962·5÷23=41·85

Andalusite has therefore the atomic volume of Spodumene, for C equals 41·85, while in the above it equals 43·47. Moreover the angle of the rhombic prism is nearly the same, it being in Andalusite 91° 33′, in Spodumene 93°. We may hence conclude that the crystallization of Spodumene is not oblique like the Feldspars and Petalite (although often so considered), but *trimetric* like Andalusite, and that *the two species are isomorphous.*

XIX. *Analcime*, $3\dddot{\bar{\text{A}}}\text{l}\,\dddot{\text{Si}}^2+\dot{\text{N}}\text{a}^3\,\dddot{\text{Si}}^2+6\dot{\text{H}}$,—*Sodalite*, $\text{Na Cl}+\dot{\text{N}}\text{a}^3\,\dddot{\text{Si}}+3\dddot{\bar{\text{A}}}\text{l}\,\dddot{\text{Si}}$,—*Haüyne* $2\dot{\text{C}}\text{a}\,\dddot{\text{S}}+\dot{\text{N}}\text{a}^3\,\dddot{\text{Si}}+3\dddot{\bar{\text{A}}}\text{l}\,\dddot{\text{Si}}$,—*Nosean* $\dot{\text{N}}\text{a}\,\dddot{\text{S}}+\dot{\text{N}}\text{a}^3\,\dddot{\text{Si}}+3\dddot{\bar{\text{A}}}\text{l}\,\dddot{\text{Si}}$.

These species are introduced here for comparison with Leucite. They seem to show that the monometric form in these silicates is connected with a high atomic volume, the amount exceeding that of the monoclinic as well as triclinic feldspars.

1. Analcime.

8 $\dddot{\text{Si}}$	=4618·48	*b.* atoms of bases and acid, 20.	*c.* atoms of elements, 65.
3 $\dddot{\bar{\text{A}}}\text{l}$	1925·4	A. 8391·46÷2·068 (sp. gr.) =4057·7	
3 $\dot{\text{N}}\text{a}$	1172·7	B. 4057·7÷20=202·88	C. 4057·7÷65=62·43
6 $\dot{\text{H}}$	674·88		
a. At. weight,	8391·46		

2. Sodalite.

4 $\dddot{\text{Si}}$	=2309·24	*b.* atoms of bases and acid, 11.	*c.* atoms of elements, 39.
3 $\dddot{\bar{\text{A}}}\text{l}$	1925·4	A. 6141·54÷2·29 (sp. gr. of Vesuvian var.) =2682	
3 $\dot{\text{N}}\text{a}$	1172·7	B. 2682÷11=244	C. 2682÷39=68·77
1 Na	290·9		
1 Cl	443·3	Sp. gr. of Greenland Sodalite, 2·37.	Thence C=66·45.
a. At. weight,	6141·54		

3. Haüyne.

2 $\dddot{\mathrm{S}}$ =1000 *b.* atoms of bases and acid, 14. *c.* atoms of elements, 49.

4 $\dddot{\mathrm{Si}}$ 2309·24 A. 7110·32÷2·45 (sp. gr.)=2902·2

3 $\dddot{\bar{\mathrm{A}}\mathrm{l}}$ 1925·4 B. 2902·2÷14=207·3 C. 2902·2÷49=59·23

3 $\dot{\mathrm{Na}}$ 1172·7

2 $\dot{\mathrm{Ca}}$ 709·98

a. At. weight, 7110·32

4. Nosean.

4 $\dddot{\mathrm{Si}}$ =2309·24 *b.* atoms of acids and bases, 12. *c.* atoms of elements, 43.

3 $\dddot{\bar{\mathrm{A}}\mathrm{l}}$ 1925·4 A. 6298·24÷2·3 (sp. gr.) =2738·36

4 $\dot{\mathrm{Na}}$ 1563·6 B. 2738·36÷12=228·2 C. 2738·36÷43=63·68

1 $\dddot{\mathrm{S}}$ 500·00

a. At. weight, 6298·24

XX. *Kyanite*, $\dddot{\bar{\mathrm{A}}\mathrm{l}}^3\,\dddot{\mathrm{Si}}^2$—*Bucholzite*, $\dddot{\bar{\mathrm{A}}\mathrm{l}}\,\dddot{\mathrm{Si}}$.

1. Kyanite.

Atomic weight as for Andalusite, 3080·02. A. 3080·02÷3·62 (sp. gr.) =850·83

B. 850·83÷5=170·165 C. 850·83÷23=37·0

2. Bucholzite.

1 $\dddot{\mathrm{Si}}$ = 577·31 *b.* atoms of acid and base, 2. *c.* atoms of elements, 9.

1 $\dddot{\bar{\mathrm{A}}\mathrm{l}}$ 641·80 A=1219·11÷3·4 (mean sp. gr.) =358·56

a. At. weight, 1219·11 B. 358·56÷2=179·28 C. 358·56÷9=39·84

$\dddot{\bar{\mathrm{A}}\mathrm{l}}^6\,\dddot{\mathrm{Si}}^5$ (from Bowen's and Hayes's analyses of Sillimanite) gives (G=3·41, Bowen), A=1915·8; B=174·2; C=38·32.

The true nature of the mineral bucholzite has long been in doubt on account of the varying results of analysts. Successive experimenters have placed Sillimanite with kyanite and bucholzite; and finally Prof. Silliman, Jr., has recently united the three. The above results show that the distinct chemical compounds are identical nearly in atomic volume; we may conclude therefore that three or more compounds exist, as Hermann assumed in his paper on "heteromerism;" and analysts instead of proving one another in error have in fact examined the different species.

We observe also that of the two forms of the compound $\dddot{\bar{\mathrm{A}}\mathrm{l}}^3\,\dddot{\mathrm{Si}}^2$, the *triclinic*, as before, has the higher specific gravity and lower atomic weight, and consequently the lower atomic volume.

XXI. *Leucopyrite*, Fe As—*Mispickel*, Fe S^2+Fe As,—*White Iron Pyrites*, Fe S^2.

1. Leucopyrite.

1 As =940 *c.* atoms of elements, 2.

1 Fe 350 A. 1290÷7·228 (sp. gr.) =178·47

a. At. weight, 1290 C. 178·47÷2=89·24

[If As is a double atom, then 178·47÷3=59·49]

2. Mispickel.

1 As =940 *c.* atoms of elements, 5.

2 S 400 A. 2040÷6·127 (sp. gr.)=333

2 Fe 700 C. 333÷5=66·6

a. At weight, 2040 [Considering As a double atom, 333÷6=55·5]

3. White Iron Pyrites.

2 S =400 — *c.* atoms of elements, 3.
1 Fe 350 — A. 750÷4·76 (sp. gr.) =157·56

a. At. weight, 750 — C. 157·56÷3=52·52

The atomic volumes of these minerals are,

If As is a single atom,	89·24	66·6	52·52
If As is a double atom,	59·49	55·5	52·52

These species have each a rhombic form; but as Prof. G. Rose has observed, they appear to differ too widely to be considered isomorphous. The angles M : M are respectively 122°26′, 111°53′ and 106°30′. This chemist also remarks that the elements arsenic and sulphur are very different in crystallization, and therefore we have no good authority for assuming them to be isomorphous. If we admit As to be a single atom the atomic volumes are widely different; but if a double atom, they approximate rather closely.

In this connection, the atomic volume of *olivenite* (with which *Libethenite* is isomorphous) may be stated. The rhombic prism has M : M $(\infty P) = 109°10'$, $\breve{P}\infty = 84°45'$; while in white iron pyrites $\infty P = 106°30'$ and $\breve{P}\infty = 81°50'$, in Mispickel $\infty P = 111°53'$ and $\breve{P}\infty = 80°8'$.

1. Olivenite.

$\tfrac{3}{4}\,\overset{:\cdot:}{\bar{\text{As}}}$ =1080·06 — *b.* atoms of acids and bases, 6. — *c.* atoms of elements, 16.
$\tfrac{1}{4}\,\overset{:\cdot:}{\bar{\text{P}}}$ 223·1 — A. 3402·04÷4·135 (sp. gr.) =822·74
4 $\dot{\text{Cu}}$ 1986·4 — B. 822·74÷6=137·12 — C. 822·74÷16=51·42
1 $\dot{\text{H}}$ 112·48 — [If As is a double atom, then *c*=17, and C=48·4.]

a. At. volume, 3402·04

2. Libethenite.

1 $\overset{:\cdot:}{\bar{\text{P}}}$ = 892·3 — *b.* atoms of acid and bases, 6. — *c.* atoms of elements, 16.
4 $\dot{\text{Cu}}$ 1986·4 — A. 2991·18÷3·7 (sp. gr.) =808·43
1 $\dot{\text{H}}$ 112·48 — B. 808·43÷6=134·74 — C. 808·43÷16=50·53

a. At. volume, 2991·18

XXII. *Nitrate of Soda—Carbonate of Manganese—Carbonate of Zinc—Light Red Silver Ore.* (see p. 220.)

1. Nitrate of Soda, $\dot{\text{Na}}\,\overset{:\cdot:}{\text{N}}$; R : R=106° 33′.

1 $\dot{\text{Na}}$ = 390·9 — *b.* atoms of acid and base, 2. — *c.* atoms of elements, 8.
1 $\overset{:\cdot:}{\text{N}}$ 675·06 — A. 1065·96÷2·1 (sp. gr.) =507·6

a. At. weight, 1065·96 — B. 507·6÷2=253·8 — C. 507·6÷8=63·45

2. Carbonate of Manganese, $\dot{\text{Mn}}\,\ddot{\text{C}}$; R : R=106°51′.

1 $\dot{\text{Mn}}$ = 444·7 — *b.* atoms of acid and base, 2. — *c.* atoms of elements, 5.
1 $\ddot{\text{C}}$ 275· — A. 719·7÷3·592=200·4

a. At. weight, 719·7 — B. 200·4÷2=100·2 — C. 200·4÷5=40·1

3. Carbonate of Zinc, $\dot{\text{Zn}}\,\ddot{\text{C}}$, R : R=107°40′.

1 $\dot{\text{Zn}}$ = 506·6 — *b.* atoms of acid and base, 2. — *c.* atoms of elements, 5.
1 $\ddot{\text{C}}$ 275· — A. 781·6÷4·4 (sp. gr.) =177·6

a. At. weight, 781·6 — B. 177·6÷2=88·8 — C. 177·6÷5=35·5

4. Light Red Silver Ore, $3\mathrm{Ag\,S}+\mathrm{As\,S}^3$; R : R=107°36′.

3 Ag =4050·00 *b.* atoms of base and acid, 2. *c.* atoms of elements, 10.
1 As 940·08 A. 6190·08÷5·5=1125
6 S 1200·00 B. 1125÷2=562·5. C. 1125÷10=112·5.
a. At. weight, 6190·08 C′. 1125÷11 (if As is double) =107

5. Dark Red Silver Ore, $3\mathrm{Ag\,S}+\mathrm{Sb\,S}^3$.

3 Ag =4050·0 A. 6362·80÷5·8 (sp. gr.) =1183
Sb 1612·8 C. 1183÷10=118·3
6 S 1200·
a. At. weight, 6862·8

C in nitrate of soda and carbonate of manganese (which are nearly alike in angle) is as 2 : 3. Carbonate of zinc, isomorphous with carbonate of manganese, has C = 35·5, the angle R : R being a degree larger. The relation between C in carbonate of zinc and light red silver ore (in which the angle is nearly the same) approaches closely 1 : 3,—three times C of zinc being 106·5, while C in the silver ore is 112·5.

XXIII. *Arragonite,* M : M, 116°10′—*White Lead ore,* 117°13′—*Strontianite,* 117°19′—*Witherite,* 118°30′—*Nitrate of Potash,* 119°—*Bournonite,* 115°16′.

1. Arragonite.

1 $\dot{\mathrm{Ca}}$ = 351·49 *b.* atoms of acid and base, 2. *c.* atoms of elements, 5.
1 $\ddot{\mathrm{C}}$ 275· A. 626·99÷2·93 (sp. gr.) =216
a. At. weight, 626·49 B. 216÷2=108 C. 216÷5=43·2

2. White Lead ore.

1 $\dot{\mathrm{Pb}}$ =1394·5 A. 1669·5÷6·6 (sp. gr.) =253
2 $\ddot{\mathrm{C}}$ 275·0 B. 253÷2=126·5 C. 253÷6=50·6
a. At. weight, 1669·5

3. Strontianite.

1 $\dot{\mathrm{Sr}}$ = 647·3 A. 922·3÷3·66 (sp. gr.) =252·7
1 $\ddot{\mathrm{C}}$ 275· B. 252÷2=126 C. 252÷5=50·54
922·3

4. Witherite.

1 $\dot{\mathrm{Ba}}$ = 956·5 A. 1231·5÷4·3 (sp. gr.) =286·4
1 $\ddot{\mathrm{C}}$ 275· B. 286·4÷2=143·2 C. 286·4÷5=57·3
1231·5

5. Nitrate of Potash.

1 $\dot{\mathrm{K}}$ = 588·86 *b.* atoms of acid and base. *c.* atoms of elements, 8 [or 9].
1 $\overset{\cdot\cdot\cdot\cdot\cdot}{\mathrm{N}}$ 675·06 A. 1263·92÷1·937 (sp. gr.) =652·5
a. At. weight, 1263·92 B. 652·5÷2=326·2 C. 652·5÷8=81·56

6. Bournonite.

6 Cu =2370· *c.* atoms of elements, 33.
6 Pb 7767· A. 18585·4÷5·766 (sp. gr.) =3223·3
3 Sb 4848·4 C. 3223·3÷33=97·5
18 S 3600· [3223·3÷36 (Sb being double) =89·5]
a. At. weight, 18585·4

We have added several acknowledged isomorphs that the nature of the series may be understood, preparatory for comparison with the other species. This series is,

116°10′	117°13′	117°19′	118°30′
43	50·6	50·54	57·3

In the above series there is a change of 14·3 in atomic volume for a change of 2° 20′ (or 140′) of angle. This is equivalent very nearly to 0·1 for 1′. The differences between the first and second in this series and between the third and fourth correspond nearly with this rate.

To appreciate the relation of atomic volume between nitrate of potash, and the other species of the series, we compare it with witherite which is nearest it in angle, and find the ratio nearly of 3:2. With reference to bournonite, we should compare with arragonite, which is nearest it in angle; or perhaps more correctly with a number still smaller than the atomic volume of arragonite, since the angle is nearly a degree less. The true ratio we cannot decide upon without further investigation.

We observe that the atomic volume in the arragonite series increases with the angle while, as shown by Kopp, it diminishes in the calc series. Moreover the species with a prismatic form have a higher atomic volume than the rhombohedral; and in the species calc spar the two series overlap.

$\dot{\mathrm{Zn}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{Mg}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{Fe}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{Mn}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{Ca}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{Pb}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{Sr}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{Ba}}\,\ddot{\mathrm{C}}$
107°46′	107°25′	107°0′	106°51′	105°15′			
35·5	36·25	37·70	40·1	46·24			
				43·	50·6	50·54	57·3
				116°10′	117°13′	117°19′	118°30′

We should hence expect that if either of these species were dimorphous like calc spar, it would be those nearest to calc spar.

The species chrysolite and those of that series differ from arragonite in having M : M = 119° – 120°, and as the angle of the arragonite series enlarges, the crystallization of the two approximates. The atomic volume of the chrysolite series varies from 40 to 46, and this is near arragonite.

We add here the calculations for two species, one of which approaches chrysoberyl and the other arragonite.

Copper glance (Ȼu S) has M:M=119°35′, and a brachydiagonal prism =125°40′, while chrysoberyl has M : M=119°51′ and a brachydiagonal prism =180°.

Ȼu = 793·2 A. 993·2÷5·7 (sp. gr.) =174
S 200· C. 174÷3=58
993·2 [or if Ȼu is a single atom, 174÷2=87]

As 2Cu is isomorphous with 1Ag and other metals, the last value of the atomic volume appears to be most correct. This gives the ratio to the chrysolite series of 3 : 2. Serpentine has 44, to which if one-half be added, it becomes the atomic volume very nearly of copper glance.

Brittle Silver Ore (Sprödglaserz$=6\text{Ag S}+\text{Sb S}^3$) has M : M=115°39′, and one of its brachydiagonal prisms 72°32′; while arragonite has the corresponding angles 116°10′ and 69°22′.

6 Ag =8100· A. 11512·8÷6·5=1771
1 Sb 1612·8 C 1771÷16=110·7
9 S 1800·
11512·8

This result gives the ratio of 3 : 1.

We do not decide here whether these minerals are proper isomorphs or not of the groups with which they are compared.

Topaz in one position has nearly the axes of chrysoberyl. They are given by von Kobell as follows—

For Chrysoberyl, 0·5800 : 1 : 0·4702
For Topaz, 0·4745 : 1 : 0·5281

and the latter is the same approximately as the former reversed.

Calculating the atomic volume of topaz $(\text{Al F}^3+\text{Si F}^3)+2\ddot{\bar{\text{A}}}\text{l}^3\,\ddot{\bar{\text{S}}}\text{i}^2$, we find

4 $\ddot{\bar{\text{S}}}\text{i}$ = 2309·24 *c.* atoms of elements, 55.
6 $\ddot{\bar{\text{A}}}\text{l}$ 3850·80 A. 8204·15÷3·5(sp. gr,) =2344·0
2 Al 341·8 C. 2344÷55=42·6
6 F 1425·0
1 Si 277·31
8204·15

The atomic volume thus corresponds with that of the chrysolite series.

The following are some comparisons of dimetric and hexagonal species, alike in the length of the vertical axis. The coincidences of atomic volume cannot be deemed accidental.

	Axis.	Atomic volume.
Vesuvian, *dimetric,*	0·5345	44·64
Dioptase, *rhombohedral,*	0·5295	45·44
Rutile, *dimetric,*	0·6555	40·7
Arsenic, *rhombohedral,*	0·6938	163 (=4×40·75)
Scapolite, *dimetric,*	0·44	54·
Nepheline, *rhombohedral,*	0·4629	56·66
Beryl, "	0·4993	53·46
Tungsten, *dimetric,*	1·0488	50·3
Chabazite, *rhombohedral,*	1·0798	51·5

It is obvious that these observations are but the introduction to a subject of great extent, and of the widest interest to science.

I defer for another occasion what had been prepared upon the monometric species, and conclude with a table of the results here published, and a brief enunciation of some of the conclusions flowing from the facts detailed.

A TABULAR VIEW OF THE RESULTS.

The relations of atomic volume will be at once apparent from the following table; 1, as exhibited in the column of aggregate atomic volumes (column A),—2, in that of the aggregate divided by the number of atoms of acids and bases (column B),—3, that of the aggregate divided by the number of atoms of the elements (column C).

1. *Crystallization clinometric.*

	A.	B.	C.
1. Pyroxene, monoclinic, 1st var., $(\dot{\mathrm{Ca}}, \dot{\mathrm{Mg}})^{3} \dddot{\mathrm{Si}}^{2}$,	637·	127·4	45·5
2d var., $(\dot{\mathrm{Ca}}, \dot{\mathrm{Mg}}, \dot{\mathrm{Fe}})^{3} \dddot{\mathrm{Si}}^{2}$,	645·2	129·	46·1
3d var., (Hedenbergite,)	673·4	134·7	48·1
4th var., (Hudsonite,)	706·0	141·2	48·9
5th var., $\dot{\mathrm{Fe}}^{3} \dddot{\mathrm{Si}}^{2}$,	674·7	135·	48·2
6th var., $\dot{\mathrm{Mn}}^{3} \dddot{\mathrm{Si}}^{2}$,	684·8	136·9	48·9
2. Acmite, monoclinic,	918·5	183·7	48·34
3. Hornblende, " 1st var.,	971·6	138·8	48·58
2d var., (aluminous,)	. .	155·95	47·25
3d var., "	. .	138·4	48·48
4th var.,	. .	144·0	48·24
4. Borax, monoclinic,	1391·6	107·0	46·38
5. Glauber salt, "	1290·5	107·54	49·6
1. Epidote, monoclinic,	1268·	158·5	45·285
2. Zoisite, "	1237·	154·6.	44·2
3. Orthite of the Urals, monoclinic,	1921·	147·8	48·025
4. Orthite of Hitteroe, "	1017·	145·3	48·48
1. Orthoclase, monoclinic,	1388·	231·3	60·4
2. Ryacolite, "	867·	216·7	57·8
3. Loxoclase, "	1063·	212·6	56·0
4. Baulite, "	2178·1	217·81	55·85
5. Albite, triclinic,	1280·4	213·4	55·07
6. Labradorite, "	795·5	198·9	58·03
7. Oligoclase, "	1038·3	207·66	54·647
8. Anorthite, "	1959·	195·9	52·95
9. Voegite, "	2166·5	197·	52·84
10. Andesine, "	2912·4	208·	55·0
11. Petalite, "	6071·8	224·96	57·3
1. Kyanite, triclinic, $\dddot{\mathrm{\bar{A}l}}^{3} \dddot{\mathrm{Si}}^{2}$,	850·83	170·165	37·0
2. Bucholzite, " $\dddot{\mathrm{\bar{A}l}} \dddot{\mathrm{Si}}$,	358·56	179·28	39·84
3. Sillimanite, $\dddot{\mathrm{\bar{A}l}}^{6} \dddot{\mathrm{Si}}^{5}$ (Bowen's analysis),	1915·8	174·2	38·32
1. Chromate of lead, monoclinic,	333·8	166·9	55·6
2. Monazite, "	617·25	154·3	51·44

2. *Hexagonal or Rhombohedral.*

	A.	B.	C.
1. Specular iron, 85°58′,	192·	. .	38·4
2. Alumina, (Corundum,) 86°04′,	161·7	. .	32·3
3. Phenacite, 83°12′,	354·	88·5	35·4
4. Arsenic, 85°04′,	. .	. .	163·
5. Antimony, 87°35′	. .	. .	240·65
6. Bismuth, 87°40′,	. .	. .	135·75
7. Tellurium, 86°57′,	. .	. .	129·36
8. Osmium, 84°52′,	. .	. .	124·26
1. Quartz, 94°15′,	218·	. .	54·5
2. Chabazite, 94°46′,	4582·4	143·	51·5
1. Cinnabar, 71°47′,	180·	. .	90·
2. Eudialyte, 73°40′,	2382·	183·2	58·1
1. Beryl, (old at. wt. of Glucina,)	2512·7	228·4	53·46
2. Nepheline,	1473·2	210·5	56·66
1. Talc, $\dot{\mathrm{Mg}}^3\,\dddot{\mathrm{Si}}^4$,	1188·	162·57	51·73
2. " $\dot{\mathrm{Mg}}^4\,\dddot{\mathrm{Si}}^5$,	1446·	160·7	51·64
3. " $\dot{\mathrm{Mg}}\,\dddot{\mathrm{Si}}$,	308·1	154·	51·35
1. Carbonate of lime, 105°05′, (from Kopp,)	231·20	165·60	46·24
2. " lime and magnesia (dolomite,) 106°15′,	202·36	101·18	40·47
3. " manganese, 106°51′,	200·4	100·2	40·1
4. Nitrate of soda, 106°33′,	507·6	253·8	63·45
5. Carbonate of iron, 107°,	188·50	94·25	37·70
6. " iron and magnesia, (mesitine,) 107°14′,	186·26	93·13	37·25
7. " magnesia, 107°25′,	181·25	90·62	36·25
8. " zinc, 107°40′,	177·6	88·8	35·5
9. Light red silver ore, 107°36′,	1125·	562·5	112·5
10. Dark red silver ore, 108°18′,	1183·	591·5	118·3

3. *Crystallization trimetric.*

	A.	B.	C.
1. Chrysoberyl, (new atomic weight,)	216·18	108·9	30·9
" old atomic weight,	1300·9	185·8	37·16
" von Kobell's at. wt.,	433·7	144·6	36·14
2. Chrysolite,	416·	104·	41·6
3. Villarsite,	1916·3	100·86	41·65
4. Serpentine,	2068·5	109·	44·9
5. Epsom salt,	881·	98·	44·
6. Picrosmine,	1587·	122·	46·68
1. Topaz,	2344·	. .	42·6
1. Sulphur,	98·4	. .	98·4
2. Scorodite,	894·73	149·12	47·1
3. Selenium, (acknowledged isomorphous with sulphur,)	115·	. .	115·
1. White iron pyrites, (dimorph with common pyrites,) 106°36′,	157·56	. .	52·52
2. Graphic tellurium, 107°44′,	1137·5	. .	113·75
3. Celestine, 104°,	294·2	147·1	49·
4. Heavy spar, 101°40′,	323·64	161·82	53·94
5. Anglesite, 103°49′,	301·67	150·83	50·27

	A.	B.	C.
1. Andalusite,	962·5	192·5	41·85
2. Spodumene,	3216·7	169·3	43·47
1. Leucopyrite—As, a single atom,	178·47	. .	89·24
As, a double atom,	. .	. .	59·49
2. Mispickel —As, a single atom,	333·	. .	66·6
As, a double atom,	. .	. .	55·5
3. White iron pyrites, (as above,)	157·56	. .	52·52
4. Olivenite,	822·74	137·12	51·42
5. Libethenite,	808·43	134·74	50·53
1. Arragonite, 116°10′,	216·	108·	43·2
2. White lead ore, 117°13′,	253·	126·5	50·6
3. Strontianite, 117°19′,	252·	126·	50·54
4. Witherite, 118°30′,	286·4	143·2	57·3
5. Nitrate of potash, 119°,	652·5	326·2	81·56
6. Bournonite, 115°16′,	3228·3	. .	97·5
1. Copper glance, 119°35′,	174·	. .	58 or 67
1. Brittle silver ore,	1771·	. .	110·7

4. *Crystallization dimetric.*

1. Scheelite, (tungstate of lime,)	301·6	150·8	50·3
2. Tungstate of lead,	355·9	177·9	59·3
3. Fergusonite,	967·5	138·2	57·0
1. Zircon,	370·3	185·15	41·15
2. Rutile,	122·3	. .	40·7
3. Tin ore,	134·4	. .	44·8
1. Scapolite,	1729·4	192·1	54·
2. Meionite,	1558·2	194·8	55·65
3. Wernerite,	1909·	190·9	51·6
4. Dipyre,	2816·	201·1	55·21
5. Barsowite,	2133·	194·	52·
6. Wernerite, Pargas,	1371·1	196·	52·7
7. Gehlenite (Rammelsberg's analysis),	2505·8	156·6	51·13
1. Idocrase,	848·16	141·36	44·64
1. Anatase,	134·0	. .	44·66
2. Horn quicksilver,	261·3	. .	130·65

5. *Crystallization monometric.*

1. Leucite,	3343·	238·8	63·08
2. Analcime,	4057·7	202·88	62·43
3. Haüyne,	2902·2	207·3	59·23
4. Nosean,	2738·36	228·2	63·68
5. Sodalite—Sp. gr.=2·29,	2682·	244·	68·77
Sp. gr.=2·37,	. .	. .	66·45

Conclusions from the preceding facts.

I. The law of Isomorphism, in view of the facts detailed, has greatly widened limits. It includes the received law—Like or homologous compounds of isomorphous elements are isomorphous; and also the more general law,—Unlike compounds, of the same or different elements, may be isomorphous, and when so, they are alike or proportional in atomic volume.

II. Cleavage may differ among substances, and yet the species be isomorphous. Thus augite and hornblende have different cleavage; anatase and horn quicksilver; sulphur and scorodite. This is a point, however, which requires much more investigation.

III. The relations of atomic volume shown in the three columns are all of interest, but especially those in the *third* or C column. The C relation is seen to be in general a relation of approximate *equality*, while the A relation when simple is usually one of multiple ratio; and sometimes it is far from simple. The C relation exhibits the comparative character of the monoclinic, triclinic and monometric feldspars, in a simple and obvious manner, while from the A relation, no deduction could be made: and so in other cases where general principles are concerned. The C relations often show a consistent difference between a substance with its allies and others unlike, when no such difference is apparent in the A relations. The C relation moreover exhibits the differences which are compatible with a ratio of equality, and hence enables us to compare more correctly the A relations. It is unnecessary to review here the ratios in the C column. We mention only a few cases of the ratios (approximate) apparent in the A column which in many cases are simple and deserve full consideration. We take the number for the species first mentioned in each paragraph as the unit for comparison with the others.

1. Pyroxene, dif. var., 1; acmite 1½; hornblende 1⅓; borax 2; glauber salt 2.

2. Epidote 1; zoisite 1; Ural orthite 1⅓; Hitteroe orthite ⅘.

3. Orthoclase 1; ryacolite ⅔; loxoclase ¾; baulite 1⅓; albite 1; labradorite ⅔; anorthite 1½; vosgite 1½; andesine 1½; petalite 4⅓.

4. Kyanite 1; bucholzite $\frac{42}{100}$; sillimanite (one var.) 2½.

5. Quartz 1; chabazite 20. In deducing the ratio here as in other cases, we have some reference necessarily to the difference observed in the C ratios.

6. Talc, 1st var., 1; 2d var., 1½; 3d var., $\frac{27}{100}$. In the C column the numbers are nearly equal.

7. Chrysolite 1; chrysoberyl ½ (or 1); villarsite 4·6; serpentine 5; Epsom salt 3; picrosmine 3½.

8. Rutile 1; zircon 3.—9. Scheelite 1; fergusonite 3.

We do not pursue this further, as the ratios are readily deducible from the table.

IV. The view of Scheerer, that three of water may replace one of magnesia, if true, is only true for a special case or set of cases, and is subordinate to the more general law of atomic volume. If true, we should expect, in dividing the aggregate atomic volume by the number of atoms of the elements, that it would be right to reckon three atoms of water as eqivalent to one of magnesia, instead of counting each element as equal to one; but the facts observed are opposed to this course.

The Gerhardtian principle that protoxyd bases replace peroxyds, is also, when true, only a special case. The relations of the feldspars do not appear to be explicable on Gerhardt's principle; nor the relations of the varieties of scapolite or hornblende.

V. Species of the same atomic volume may be wholly unlike in crystallization, and hence volume alone does not seem to determine the form. Quartz has the atomic volume (C) of the feldspars—an interesting fact in view of their frequent association—and the A relation between it and albite is 1 : 6; yet there is no isomorphism between them. The fact that the two forms of a dimorphous substance differ but little in the calculated atomic volume, (often much less than one of the forms differs from another isomorphous with it,) appears to be a case in point. Yet if instances of dimorphism are also instances of isomerism, it is possible that the volume may actually be double that which is deduced. We have much therefore, to ascertain on this point, before we can determine the true relation of form to volume.

VI. There are difficulties in the way of applying these principles to some compounds, arising from doubts with regard to the atomic weights. But, as in the case of hydrogen, (which is doubled by the Berzelian school,) these investigations seem to afford data for arriving at the truth.

VII. Since the relations of atomic volume are exhibited through the volume of the elemental molecules of compounds, it may be inferred that *the elemental molecules are not combined together or united with one another in a compound; but that, under their mutual influence, each is changed alike and becomes a mean result of the molecular forces in action.* If the elemental molecules were actually combined, as is usually supposed, the atomic volume of the aggregate should be the atomic volume of the compound; so that in all comparisons between different substances, these aggregate results should present the true relation. But, it appears that the true atomic volume relation is found in the elemental molecules of compounds, and much less clearly or uniformly in the aggregate results. This inference is at variance with received ideas on chemical combination; yet if our premises are correct—we admit they need farther investigation—we see not how to avoid it.

We add an additional word upon the name applied to isomorphism among unlike compounds. *Heteromerism*, as stated, is unmeaning, this term being the correlative of *isomerism*, which has no relation to isomorphism. *Heteromerous isomorphism* is in itself applicable; but the word *isomerous* is in use, and heteromerous, if employed at all, should correspond in signification. As the above terms are therefore objectionable, we suggest as appropriate and significant, the expressions *isonomic* and *heteronomic isomorphism;* the isomorphism being in one case between homologous substances, or those of like law or proportion in constitution,—and in the other between substances unlike in constitution.

Art. XXVI.—*Observations on the Size of the Brain in various Races and Families of Man;* by Samuel George Morton, M.D.*

I have great pleasure in submitting to the Academy the results of the internal measurements of six hundred and twenty-three human crania, made with a view to ascertain the relative size of the brain in various races and families of man.

These measurements have been made by the process invented by my friend, Mr. J. S. Phillips, and described in my Crania Americana, p. 253, merely substituting leaden shot, one-eighth of an inch in diameter, in place of the white mustard-seed originally used. I thus obtain the *absolute capacity of the cranium, or bulk of the brain, in cubic inches;* and the results are annexed in all those instances in which I have had leisure to put this revised mode of measurement in practice. I have restricted it, at least for the purpose of my inferential conclusions, to the crania of persons of sixteen years of age and upwards, at which period the brain is believed to possess the adult size. Under this age, the capacity-measurement has been resorted to only for the purpose of collateral comparison; nor can I avoid expressing my satisfaction at the singular accuracy of this method, since a skull of a hundred cubic inches, if measured any number of times with reasonable care will not vary a single cubic inch.

All these measurements have been made with my own hands. I at one time employed a person to assist me; but having detected some errors in his measurements, I have been at the pains to revise all that part of the series that had not been previously measured by myself. I can now, therefore, vouch for the accuracy of these multitudinous data, which I cannot but regard as a novel and important contribution to Ethnological science.

I am now engaged in a memoir which will embrace in detail the conclusions that result from these data; and meanwhile I submit the following tabular view of the prominent facts. (See opposite page.)

The measurements of children, idiots and mixed races are omitted from this table, excepting only in the instance of the Fellahs of Egypt, who, however, are a blended stock of two *Caucasian* nations,—the true Egyptian and the intrusive Arab, in which the characteristics of the former greatly predominate.

No mean has been taken of the Caucasian race† collectively, because of the very great preponderance of Hindu, Egyptian and

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* From the Proceedings of the Academy of Natural Sciences, Philadelphia, October, 1849.

† It is necessary to explain what is here meant by the word *race.* Further researches into Ethnographic affinities will probably demonstrate that what are now termed the *five races* of men, would be more appropriately called *groups;* that each

Table showing the Sizes of the Brain in cubic inches, as obtained from the internal measurement of 623 Crania of various Races and Families of Man.

Races and Families.	No. of Skulls.	Largest I. C.	Smallest I. C.	Mean.	Mean.
MODERN CAUCASIAN GROUP.					
Teutonic Family.					
Germans,	18	114	70	90	92
English,	5	105	91	96	
Anglo-Americans,	7	97	82	90	
Pelasgic Family. Persians, Armenians, Circassians,	10	94	75	84	
Celtic Family. Native Irish,	6	97	78	87	
Indostanic Family, Bengalees, &c.	32	91	67	80	
Semitic Family. Arabs,	3	98	84	89	
Nilotic Family. Pellahs,	17	96	66	80	
ANCIENT CAUCASIAN GROUP.					
From the Catacombs. Pelasgic Family. Græco-Egyptians,	18	97	74	88	
From the Catacombs. Nilotic Family. Egyptians,	55	96	68	80	
MONGOLIAN GROUP.					
Chinese Family.	6	91	70	86	
MALAY GROUP.					
Malayan Family.	20	97	68	86	85
Polynesian Family.	3	84	82	83	
AMERICAN GROUP.					
Toltecan Family.					79
Peruvians,	155	101	58	75	
Mexicans,	22	92	67	79	
Barbarous Tribes Iroquois, Lenapé, Cherokee, Shoshoné, &c.	161	104	70	84	
NEGRO GROUP.					
Native African Family.	62	99	65	83	83
American-born Negroes.	12	89	73	82	
Hottentot Family.	3	83	68	75	
Alforian Family. Australians,	8	83	63	75	

Fellah skulls over those of the Germanic, Pelasgic and Celtic families. Nor could any just *collective* comparison be instituted between the Caucasian and Negro groups in such a table, unless the small-brained people of the latter division (Hottentots, Bushmen and Australians) were proportionate in number to the Hindoos, Egyptians and Fellahs of the other group. Such a computation, were it practicable, would probably reduce the Caucasian average to about 87 cubic inches, and the Negro to 78 at most, perhaps even to 75, and thus confirmatively establish the difference of at least nine cubic inches between the mean of the two races.

Large as this collection already is, a glance at the Table will show that it is very deficient in some divisions of the human family. For example, it contains no crania of the Eskimaux, Fuegians, Californians or Brazilians. The skulls of the great divisions of the Caucasian and Mongolian races are also too few for satisfactory comparison, and the Sclavonic and Tchudic (Finnish) nations, together with the Mongol tribes of Northern Asia and China, are among the especial *desiderata* of this collection.

Among the facts elicited by this investigation are the following:

1. The Teutonic or German race, embracing, as it does, the Anglo-Saxons, Anglo-Americans, Anglo-Irish, &c., possesses the largest brain of any other people.
2. The nations having the smallest heads, are the ancient Peruvians and Australians.
3. The Barbarous tribes of America possess a much larger brain than the demi-civilized Peruvians or Mexicans.
4. The ancient Egyptians, whose civilization ante-dates that of all other people, and whose country has been justly called "the cradle of the arts and sciences," have the least-sized brain of any Caucasian nation, excepting the Hindoos; for the very few Semi-

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of these groups is again divisible into a greater or smaller number of primary races, each of which has expanded from an aboriginal nucleus or centre. Thus I conceive that there were several centres for the American group of races, of which the highest in the scale are the Toltecan nations, the lowest the Fuegians. Nor does this view conflict with the general principle, that all these nations and tribes have had, as I have elsewhere expressed it, a common origin; inasmuch as by this term is meant only an indigenous relation to the country they inhabit, and that collective identity of physical traits, mental and moral endowments, language, &c., which characterizes all the American races. The same remarks are applicable to all the other human races; but in the present infant state of Ethnographic science, the designation of these primitive centres is a task of equal delicacy and difficulty. I may here observe, that whenever I have ventured an opinion on this question, it has been in favor of the doctrine of *primæval diversities* among men,—an original adaptation of the several races to those varied circumstances of climate and locality, which, while congenial to one are destructive to the other; and subsequent investigations have confirmed me in these views. See *Crania Americana*, p. 8; *Crania Ægyptiaca*, p. 37; *Distinctive Characteristics of the Aboriginal Race of America*, p. 36; *American Journal of Science and Arts*, 1847; and my *Letter to J. R. Bartlett, Esq.*, in vol. ii. of the Transactions of the Ethnological Society of New York.

tic heads will hardly permit them to be admitted into the comparison.

5. The Negro brain is nine cubic inches less than the Teutonic, and three cubic inches larger than the ancient Egyptian.

6. The largest brain in the series is that of a Dutch gentleman, and gives 114 cubic inches; the smallest head is an old Peruvian, of 58 cubic inches; the difference between these two extremes is no less than 56 cubic inches.

7. The brain of the Australian and Hottentot falls far below the Negro, and measures precisely the same as the ancient Peruvian.

8. This extended series of measurements fully confirms the fact stated by me in the Crania Americana, that the various artificial modes of distorting the cranium, occasion no diminution of its internal capacity, and consequently do not affect the size of the brain.

Art. XXVII.—*Remarks on the Aneroid Barometer*; by Professor J. Lovering of Harvard University.

Most of the scientific journals of Europe and America have published descriptions of the new French barometer, as it is called. For the construction of the instrument and the history of its invention I may refer to them, particularly to that contained in this Journal, September, 1849.

The two ordinary statical ways of measuring forces are, 1st, by means of gravity, and 2d, by elasticity. Our common balances to measure weight employ either the gravity of a known counterpoise or the elasticity of a spring. In like manner the weight of a column of the atmosphere is determined when we know the height of a similar column of some known fluid which it is able to support or the elasticity of some familiar substance with which it is in equilibrium. The barometer with which all have long been familiar employs the first method. The aneroid barometer, which, as its name implies, excludes all liquids from its construction, is based on the last principle, viz., that of measuring weight by elasticity.

This new instrument is already manufactured in large numbers in France and Great Britain. Its adoption is recommended on the ground of accuracy as well as its great strength and compactness. Barometers are now extensively used, not only for tracing out the grand laws of meteorology, but also as a practical guide to the mariner to forewarn him of approaching storms, and an indispensable instrument of research to the physical geographer and geologist. It is highly important that the mineralogist, the navigator and the student of general science should know what degree of accuracy may be claimed for the new barometer and how far they are allowed to trust themselves to its indications. With the hope of assisting those who desire to form an opinion on this subject, I present the following experiments and observations, undertaken originally at the suggestion of Prof. A. D. Bache, Superintendent of the U. S. Coast Survey. The instrument employed in this research was furnished by Prof. Bache, and bears the mark 1265, Lerebours and Secretan, Paris.

A series of experiments was first made with this aneroid barometer to determine the whole range of the instrument. For this purpose, it was placed first under the receiver of an exhausting pump, and afterwards under the receiver of a condensing engine. In this way, it was found capable of indicating a change of atmospheric pressure which would move the column of mercury in a common barometer from about twenty inches up to thirty-one inches. From the nature of its construction, the index cannot go beyond the point which corresponds to twenty inches of the mercurial barometer on one side, or that which corresponds to thirty-one inches of the same on the other. How accurately its march between these limits agrees with that of the mercurial barometer will appear from an examination of Table I. The pressure of the air in the receiver of the pump was obtained from the mercurial pump-gauge, which was supplied with common mercury and corrected for level and capillarity. This table shews that, while the index of the aneroid barometer is able to move, it moves farther than the column of mercury under the same change of atmospheric pressure. As it approaches its lower limit, however, it will begin of course to be restrained in the amplitude of its motion, until, at length, the difference between the two instruments changes its sign. It is obvious that, in the particular instrument examined at least, and for long ranges, similar changes of pressure are not marked by equal quantities of motion in the index in all parts of the scale. This might be expected in an instrument where no consideration is given to the distinction between potential and apparent leverage. Besides this which may be called the instrumental error, there is an irregularity in the motion of the index, arising from friction, bending, or some other cause, which would interfere seriously with the accuracy of its indications even if the arc over which the index moves were so graduated as to eliminate the instrumental error.

At the meeting, in 1848, of the British Association for the Advancement of Science, it was stated by Mr. Lloyd that one of his friends had made a similar experiment to that I have described, and that the indications of the aneroid barometer corresponded to those of the pump-gauge to within ·01 of an inch. Such is the statement in the London Atheneum, although I find no mention made of the subject in the Report of the Association for that year. As the reader is not informed to what amount of diminished pressure the aneroid barometer was subjected in this case, and whether the difference above mentioned was the result of a single observation or the mean residuum of many, he is not able to decide how far the experiments to which Mr. Lloyd refers are at variance with those here published. I cannot say how much of the error manifested in my comparison of the two barometers is fairly to be charged to the general character of the new barometer, and how much is peculiar to the single instrument with which I experimented. As soon as an opportunity offers, I desire to submit other specimens of the aneroid barometer of English and French construction to the same trial.

My next series of experiments consisted in a comparison of the aneroid barometer, day by day, with the common barometer, under the ordinary changes of atmospheric pressure. The mercurial barometer used for the purpose was made by W. & S. Jones, London, and is the same as that employed by Prof. Farrar in his barometric observations published in Volume III. of the Memoirs of the American Academy, Boston. This instrument is furnished with an adjustment for level, an attached thermometer and a scale of corrections for temperature. This correction as well as that for capillarity has been applied to my observations. In this series of experiments it was necessary to know how much the aneroid barometer was affected by a change of temperature. Only a partial compensation is attempted in the construction of the instrument. An increase of temperature tends to make the air in the reservoir expand in the same way as diminished pressure. But the same increase of temperature, by enlarging the metallic surfaces of the reservoir and increasing its capacity, may sometimes even over-compensate for the increased elasticity of the contained gas. In the instrument which I used the compensation fell short; and the amount of the deficiency was determined by exposing the barometer side by side with a thermometer to a temperature of 32° Fah. and reading the index, and then exposing it to a high temperature (in some instances as high as 140° Fah.) and reading the index once more. The difference of the two readings divided by the difference of the two temperatures was adopted as the correction for a single degree and was applied to each of the observations. The value of this correction as obtained from the mean of five experiments is ·0021 of an inch, with the same sign as in the mercurial barometer. The aneroid barometer in my possession was not provided (as is sometimes the case) with an attached thermometer. A thermometer by the side of it and not under the same case as the air-chest will not indicate the exact temperature of the working parts of the instrument. The slowness with which the index returned to its old mark, after the barometer had been subjected to excessive heat or cold and was then restored to a medium temperature, manifests the importance of having the thermometer inclosed as the rest of the instrument. The standard of temperature adopted was 55° Fah. to accommodate the scale of the mercurial barometer.

The result of this series of comparisons is contained in Table II. Although the agreement is much closer than with the low ranges, it falls far below the requirements of nice scientific investigations. Mr. David Purdie Thompson in his very recent "Introduction to Meteorology," has the following paragraph. "Upon comparison of indications made with the aneroid barometer—not corrected for the particular temperature—and a very perfect mercurial barometer, given by Mr. Dent, we find that from forty-nine observations made between the 6th of January and 23d of February, 1848, the mean difference was 0·037 of an inch, the *aneroid* being in excess; and from sixty similar observations made with a standard barometer, during December, 1848, and between the 3d and 31st of January, 1849, the mean difference amounted to 0·026 of an inch, the *mercurial* being, in this case, in excess over the aneroid barometer. Combining these observations (109 in number) a mean difference amounting to 0·0025 of an inch is found to exist, the indications of the aneroid being in excess. For general use the instrument is thus shown to be well suited; for the measurement of heights it is peculiarly adapted, from its portability and comparative strength; and for nautical purposes we know of no better instrument."—p. 448.

Now it will be observed that the mean difference in the twenty-eight comparisons of the two barometers which I have given amounts to only ·040 of an inch. So far as can be inferred from the value of the mean differences, the comparisons were as satisfactory as in the first set given by Mr. Thompson. Still the single differences are large; whether larger or smaller than in Mr. Dent's observations I am not able to say, as Mr. Thompson has not given the individual differences. Provision has been made in the construction of the instrument for diminishing the mean difference as we alter the general rate of a chronometer. If the mean difference is eliminated from the comparisons and the remaining differences are placed in a column as in Table II, they manifest by the signs of plus and minus the irregularities of the instrument in small ranges and the errors to be expected from these irregularities in single observations. I have arranged the same observations in Table III, according to the sign and the value of these remaining differences. From the sign of the differences it appears that when the barometers fall the aneroid falls most, and when the barometers rise the aneroid rises most. In other words, the aneroid index moving on either side of the point where it agrees with the mercurial barometer moves too fast.

The experiments with the air-pump indicate the same tendency more unequivocally and to about the same proportional amount. For in these experiments, where the barometer and the pump-gauge were indicating the effect of diminished pressure, the aneroid stood at the lowest point; so that when the elevation of the mercury in the pump-gauge is subtracted from the backward motion of the index in the aneroid the sign is always plus: at least, until the lower limit of range is approached. Although this is the general character of the differences, a nice examination of the observations shows that here as well as in the experiments with the air-pump there are errors and fluctuations which cannot be traced to any law of the instrument, and against which no provision can be made.

Table IV. contains a series of observations made with the view of ascertaining the stability in the levers of the aneroid barometer and the firmness of other parts of the instrument. The instrument was read off before being exposed to diminished pressure: it was then noticed with what fidelity and dispatch the index returned to its original position when the original pressure was restored.

In estimating the merits of the aneroid barometer, it must not be forgotten that it is single observations, indicating momentary changes of the atmospheric pressure, on which the navigator most relies. In some of the hurricanes to which he is exposed, the barometer occasionally sinks so low as to come within the range of the experiments made with the air-pump. And yet here if any where the aneroid barometer finds its appropriate sphere. In meteorology, the barometer is the most important instrument of research. The barometer alone of all the instruments in the hands of the meteorologist is independent of merely local changes and gauges the atmosphere to its upper limit. But the range of atmospheric pressure is so limited, that laborious series of observations, with the nicest barometers that can be constructed, are necessary in order to develop the harmonies of this strangely agitated envelope of our planet. No observer would be willing to risk the value of this long labor by trusting to the new barometer until its peculiarities are better understood than at present. It may possibly happen that a long series of observations which eliminate irregularities of weather will eliminate instrumental irregularities at the same time. The same objections apply with greater force to the application of the aneroid barometer to the measurement of heights above the level of the sea. An elevation of eighty-seven feet depresses the mercury by about ·1 of an inch only; hence a small error in the barometer will entail a large error on the estimated elevation. Moreover, a very long series of observations will, in this case, be generally impracticable. I would suggest one farther consideration. The mercurial barometer is in danger of being broken when exposed to the perils of mountain-travel. In this case, the damage, however great, is known, and no error is introduced into science. Unless the tube is broken, the instrument is so simple in its construction that it is not liable to be injured at all. It is otherwise with the aneroid barometer. To appearance it is stronger than the old barometer and can bear a greater strain without being broken. On the other hand, we can easily foresee that it may be materially injured without attracting the notice of the observer at the time, and in this way may conceal its own infirmities under its apparent strength.

TABLE I.

1849.	Fall of the Aneroid Barometer under the receiver.	Rise of the mercury in the pump gauge corrected for capillarity and level.	Difference.		Fall of the Aneroid Barometer under the receiver.	Rise of the mercury in the pump gauge corrected, &c.	Difference.
Sept. 24. Thermometer not observed. Barometer 29·760.	4.27	4.258	.012+	Sept. 27. Thermometer 66. Barometer 29·940.	10.42	20.721	10.301 –
	7.78	7.673	.107+		10.40	19 338	8.938–
	10.10	15.830	5.730–		10.38	18.236	7.856–
	10 07	16.030	5.960–		10.38	17.294	6 914–
	9·78	10.150	.370–		10.36	16.282	5.922–
	9.44	9 268	.172+		10.30	15.030	4.730–
	8.46	8.216	.244+		10 02	10.140	.120–
	7.52	7.264	.256+		9 60	9.268	.332+
	6.48	6.232	.248+		8 68	8.246	.434+
	5.48	5.240	.240+		7·72	7.224	.496+
	4.45	4.388	.062+		6.79	6.332	.458+
	3 38	3.256	.124+		5.61	5.270	.340+
	2.32	2.214	.106+		4.49	4.208	.282+
					3.50	3 256	.244+
					2.36	2.254	.106+
Sept. 26. Thermometer 72·5 Fah. Barometer 29·690.	10.13	18.537	8.407–	Sept. 29. Thermometer 66·5. Barometer 80·170.	10.63	23.035	12.405–
	10.11	17.294	7.184–		10.59	16.262	5.672+
	10 11	16.382	6.272–		10.23	10.220	.010+
	10.07	15.280	5.210–		9.75	9.328	.422+
	9.75	10.220	.470–		9.02	8.426	.594+
	9.36	9.268	.092+		7.95	7.294	.656+
	8.71	8.316	.394+		6.93	6.332	.598+
	7.67	7.274	.396+		5.80	5.270	.530+
	6 67	6.262	.408+		4.63	4.238	.392+
	5.53	5.120	.410+				
	4.67	4.238	.432+		2.45	2.224	.226+
	3.34	3.206	.134+				
	2.30	2.154	.146+				

Dec. 4. The Aneroid barometer was placed under the receiver of a condensing pump and it was observed that the index only moved forward to 31, which corresponds to 31 of the mercurial barometer.

TABLE II.

1849.	Aneroid corrected for Temperature.	Mercurial corrected for level, capillarity and temperature.	Difference.	Difference after eliminating mean difference of instruments.
Dec. 10	29 932	29.977	.045–	·005–
11	30.089	30.107	.018–	.022+
12	30.439	30.507	.068–	.028–
13	30 267	30.237	.030+	.070+
14	30.122	30.117	.005+	.045+
15	30.378	30.397	.019–	.021+
16	30.148	30.147	.001+	.041+
17	29.870	29.907	.037–	.003+
18	30.327	30.327	.000	.040+
19	30.519	30.537	.018–	.022+
20	29.703	29.787	.084–	.044–
21	30.119	30.127	.008–	.032+
22	30.012	30 067	.055–	.015–
23	29.353	29.447	.094–	.054–
24	29.595	29.667	.072–	.032–
25	29.488	29.597	.109–	.060–
26	30.212	30.310	.098–	.069–
27	30.087	30.160	.073–	.033–
28	30.407	30.447	.040–	.000
29	30 025	30.090	.065–	.025–
30	30.200	30.197	.003+	.043+
31	30.115	30.147	.032–	.008+
1850.				
Jan. 2	30.360	30.407	.047–	.07 –
3	30.156	30.207	.051–	.011–
4	29.890	29.937	.047–	.07 –
5	30.125	30.137	.012–	.028+
6	30.464	30.517	.053–	.013–
7	30.340	30.367	.027–	.013+
Mean,	30.098	30.138		
"		30.098		
Diff'nce		.040–		

TABLE III.

Observations in Table II, arranged according to the amount and the sign of their differences.		
	29.597	.069–
	30.310	.058–
	29.447	.054–
	29.787	.044–
	30.160	.033–
	29.667	.032–
	30.507	.028–
	30.090	.025–
	30.067	.015–
	30.517	.013–
	30.207	.011–
	30.407	.007–
	29.937	.007–
	29.977	.005–
Mean,	30.048	.029–
	30.237	.070+
	30.117	.045+
	30.197	.043+
	30.147	.041+
	30.327	.040+
	30 127	.032+
	30.137	.028+
	30.537	.022+
	30.107	.022+
	30.397	.021+
	30.367	.013+
	30.147	.008+
	29.907	.003+
Mean,	30.212	.029+
"	30.048	
Difference,	.164	

1849. Sept. 10. The Aneroid stood at 30·39. It was placed under the receiver of an air pump and the atmospheric pressure diminished by 5 inches. When the air was admitted, the index moved forward to 30·35. It rose to 30·375 in two or three minutes. The following table embraces similar experiments with their results.

TABLE IV.

	Original reading of the Aneroid Barometer.	Reading after the air was admitted.	Difference.	Degree of rarefaction as measured by the pump-gauge.		Original reading.	Reading after the air was admitted.	Difference.	Degree of rarefaction.
Sept. 10.	30.390	30.375	.015–	5 inch	Sept. 24	29.760	29.720	.040–	16 inch.
	30·480	30.530	.050+	5 "	26	29.690	29.680	.010–	18 "
	30.375	30 360	·015–	5 "	27	29.940	29.930	.010–	20 "
	30.360	30·460	·100+	9 "	29	30.170	30.050	.120–	22 "
	30.480	30.500	·020+	5 "					
	30.530	30.530	.000	9 "					

Art. XXVIII.—*An account of some Fossil Bones found in Vermont, in making excavations for the Rutland and Burlington Railroad;* by Zadock Thompson.

In addition to the benefits derived directly from railroads in the business of travel and transportation, the cause of science and particularly the science of geology is deriving indirectly no small advantage from their construction. The deep cuttings which these works often require, expose the various strata of rocks where they have not been affected by the weather for the examination of the geologist, and the vast excavations in stratified sand and clay, and in the confused beds of drift materials, exhibit not only the relations of these to each other, but frequently disclose organic remains which shed new light upon the early history of our earth.

Only about four years have elapsed since the construction of railroads was commenced in Vermont, and at this time, nearly three hundred miles of railroad are so far completed as to be in use within the state; and, while the excavations for these roads have conduced to a more accurate knowledge of the position, age and lithological character of the rock formations, they have at the same time very unexpectedly disclosed organic remains, which are of much scientific interest and importance. In grading the line of the Rutland and Burlington Railroad, portions of the skeletons of two large animals, both belonging to the class *mammalia*, and to families which no longer exist here in a living state, were found deeply buried in the earth, and the bones were for the most part in a very good state of preservation.

Fossil Elephant.—The Rutland and Burlington Railroad passes over the range of Green Mountains in the township of Mount Holly, at an elevation of 1360 feet above the level of the sea. In the notch through which the railroad passes, and very near the dividing point between the waters which flow westward into Lake Champlain and those which run eastward into Connecticut River, there is a deep deposit of vegetable muck. The cut for the railroad is through this muck-bed. In making it the workmen, to their great astonishment, found an enormous tooth. It was resting upon gravel at the bottom of the muck, which was there about nine feet deep. It was in a very good state of preservation, weighed eight pounds, and measured about eight inches transversely across the crown. It was pronounced by Professor Agassiz to be a *grinder* of an extinct species of elephant. Subsequently, as the excavation was continued, the two tusks and several of the bones of this elephant were found, and it is not improbable that the remaining parts of the skeleton are still buried beneath the same muck-bed.

Fossil Cetacean.—The fossil bones, which it is more particularly the object of this paper to describe, were found on the line of the Rutland and Burlington Railroad in the month of August, 1849, in the township of Charlotte, about twelve miles south of Burlington, and a little more than one mile eastward from the shore of Lake Champlain. In widening a deep and extensive cut through stratified sand and clay, the workmen there struck upon a mass of bones. They were between eight and nine feet below the natural surface of the ground, and were very compactly bedded in fine adhesive blue clay. Little notice was taken of them at first, until some of the overseers, thinking that they observed peculiarities in the form of several of the bones, were induced to commence an examination. They soon found that the bones discovered belonged to the anterior portion of the skeleton of some unknown animal, the head of which had already been broken into fragments by the workmen, and many of the fragments carried away with the earth which had been removed. On carefully removing more of the clay, the vertebræ were found extending in a line obliquely into the bank, and apparently arranged in the order in which they existed in the living animal. These vertebræ were, as was supposed, all taken out, and together with the sternum, fragments of head, ribs, &c., forwarded to Burlington, and by the kindness of Messrs. Jackson and Boardman, engineers on the railroad, were placed in my hands.

Upon a careful examination of these bones, I ascertained that the greater part of the head, all of the teeth, and several vertebræ, ribs, and bones of the limbs, were wanting in order to complete the skeleton. To recover these if possible, I immediately visited the locality; and at this and a subsequent visit, I succeeded in obtaining most of the anterior portion of the head, nine of the teeth, and thirteen additional vertebræ, together with the bones of one forearm, several chevron bones and portions of ribs. My first object being to insure the preservation of the bones, I carefully cleansed them from the adhesive clay, and then saturated them with animal glue.

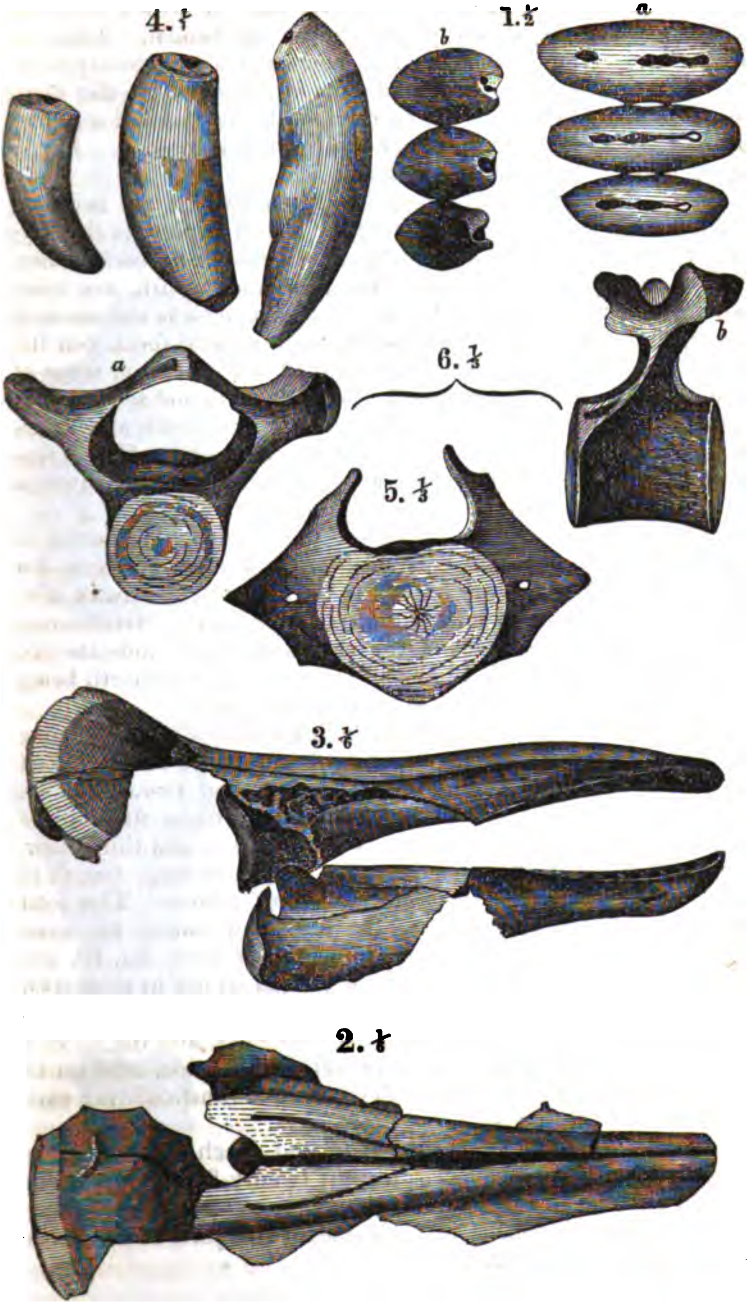
When I first looked at the bones, I was in doubt whether they belonged to an animal of the cetaceous or saurian family, but my doubt was soon removed by a careful examination of the caudal vertebræ. These I found to have their articulating surfaces convex and rounded in such a manner as to allow of very extensive vertical motion of the tail, and but very little lateral motion. This circumstance plainly indicated that the movements of the animal in the water were effected by means of a horizontal caudal fin, and that it, therefore, belonged to the family of *Cetacea.*

Fig. 1 represents the thirteenth, fourteenth and fifteenth vertebræ of the tail, showing the manner in which they move upon each other—*a*, as viewed from above—*b*, as seen laterally.—[The fraction after the No. of the figure, denotes the linear proportion of the figure to the object which it represents.]

But, if there had still remained any doubt with regard to the general character of the animal, it would have been entirely removed, when I succeeded afterwards in reconstructing out of the fragments of bones which I had procured, so much of the upper anterior portion of the head, as to exhibit distinctly its *spiracles*, or blow-holes, showing unequivocally that it belonged to the Whale family. My next object was to ascertain, if possible, whether it belonged to an extinct, or to a living species or genus of this family. By a careful examination of Cuvier's great work on Fossil Bones, I became satisfied that, in the osteology of the head, it bore a strong resemblance to a small arctic cetacean, called the *Beluga*, or white whale, (*Delphinus leucas*, *Cuv. Oss. Foss.*, v, p. 297, pl. xxii, fig. 5 and 6, Paris ed., 1825,) and that it therefore belonged rather to the living than to the extinct types; and this opinion was confirmed by Prof. Agassiz, to whose unrivaled skill and kind assistance in the investigation of these fossils I am deeply indebted.

The head of the skeleton, as already remarked, was broken into a great number of pieces, but enough of these have been recovered and matched to determine very nearly the form and entire length of the head and of one side of the lower jaw, and of its symphysis with the other side. The fragments of the anterior portion of the upper jaw were found and matched, with the exception of so much of the maxillary bone as formed the alveolar margin of the left side. The alveolar margin on the right side measures 6·85 inches in length and contains eight alveoli. In the corresponding side of the lower jaw there are seven alveoli in a length of 5·5 inches, the alveolar margin extending three inches farther backward, but not perforated for teeth. Fig. 2 represents the head, viewed from above, so far as reconstructed, and fig. 3, a side view with the lower jaw dropped a little below its true place.

It appears, from what has been said above, that the animal had seven teeth in the lower jaw and eight in the upper, on each side, making thirty teeth in the whole. The teeth are all of one kind, being conical with flat or rounded crowns, and their substance is very dense and firm. They vary in length from one to nearly two inches, with a diameter of about half an inch. Fig. 4 represents their different forms. Only nine of the teeth have been recovered, and none of these were in their places in the jaws when I obtained them; but that they were in their places up to the time the bones were first discovered by the workmen, appears evident from the fact, that, while every other cavity in the bones was filled with clay, the alveoli were all empty.


4. 1/1
1. 1/2
b
a
b
a
6. 1/3
5. 1/3
3. 1/6
2. 1/8

Of the vertebræ I have secured forty-one, of which four are cervical, eleven dorsal, ten lumbar and sixteen caudal. Three of the cervical vertebræ, the first, fifth and sixth, are evidently missing, which, with those obtained, would make *seven*, the usual number. These vertebræ are all free, not being soldered together as in the common dolphin and some other cetaceans. Fig. 5 represents the third cervical vertebra.

Of the dorsal vertebræ, the second and twelfth are missing, making their whole number thirteen. Fig. 6 represents the seventh dorsal vertebra—*a*, as seen from behind—*b*, as seen laterally.

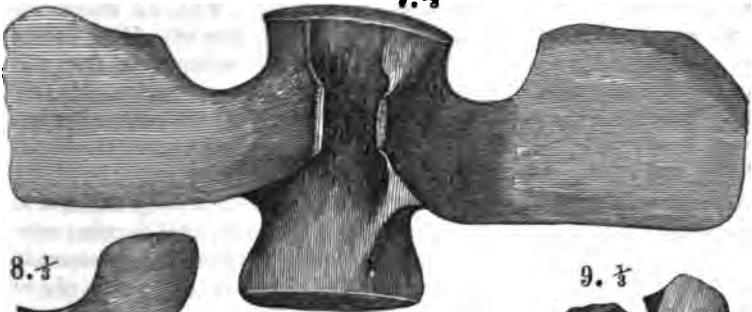
Two of the lumbar vertebræ, the sixth and twelfth, are missing, making twelve in the whole. Fig. 7 represents the seventh lumbar vertebra. They all have the same general form, but the lateral winged processes are more decayed and broken in some of them than in the one represented. The eleventh and seventeenth caudal vertebræ are missing, and perhaps a nineteenth and twentieth, making their probable whole number twenty. Fig. 8 represents the fourth caudal vertebra. The form of those towards the extremity of the tail may be seen in fig. 1.

From these statements it appears, that the whole number of vertebræ in the skeleton was fifty-two. Eleven of these are missing, two of which are known to have been taken away after they were dug up, and may perhaps be recovered. Articulating surfaces on the under sides of the caudal vertebræ, indicate five chevron bones, of which I have all but one, only the fourth being gone. Fig. 9 represents the second chevron bone.

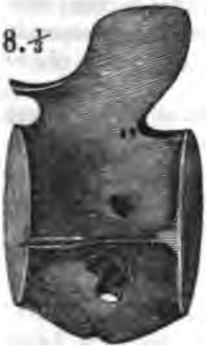
The total length of the vertebral column, (due allowance being made for the eleven missing vertebræ, but none for intervertebral cartilages,) is just ten feet, or one hundred and twenty inches. Of this length the cervical vertebræ occupy eight inches, the dorsal thirty-six, the lumbar forty-two, and the caudal thirty-four. The lumbar vertebræ are largest, having an average length of about four inches and a diameter of three inches. The total length of the animal, including the head and caudal fin, must have been at least thirteen feet. The *hyoid* bone, fig. 10, and the *sternum*, fig. 11, are both very large and strong in proportion to the size of the skeleton. The former measures eight and a half inches in a straight line from point to point, and the latter is fifteen inches long, from three to seven inches wide, and on an average nearly one inch thick. There are four articulating cavities for ribs on each side.

The ribs are considerably decayed and much broken. The longest rib, in one piece, measures just twenty-four inches along the curve. The ribs which form the anterior pair are very strong, and unbroken, and consist, on each side, of two parts of solid bone as represented in fig. 12.

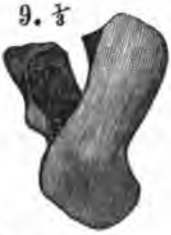
7. $\frac{1}{3}$



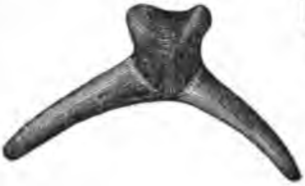
8. $\frac{1}{3}$



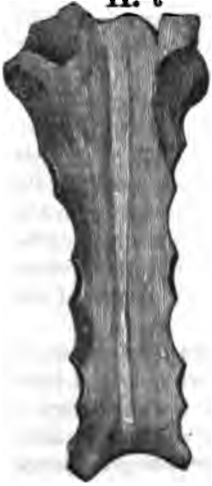
9. $\frac{1}{3}$



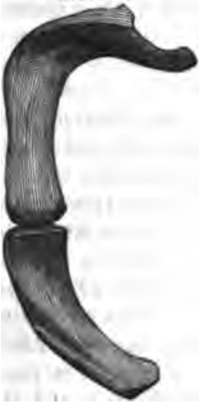
10. $\frac{1}{6}$



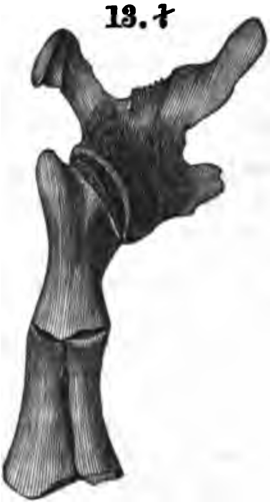
11. $\frac{1}{6}$



12. $\frac{1}{6}$



13. $\frac{1}{6}$



Of the limbs, the two scapulæ, one humerus, and the two forearm bones on one side, and the ulna of the other side, are secured; all the other bones of the fins are missing. Fig. 13 represents the recovered bones of the left fin, in their places. The height of the scapula is seven inches, the length of the humerus five, and of the forearm four inches.

There are several of the recovered bones, whose places are not yet ascertained. Some of these may be appendages to the hyoid bone and others may belong to a rudimentary pelvis. Professor Agassiz who has manifested, as already stated, a deep interest in these fossils, has kindly consented to give them that further careful investigation, and illustration, which their importance demands, and for which he is most ably qualified; I have, therefore, placed them in his hands for that purpose.

The following measurements of the head, are all that I have been able to make, which admit of direct comparison with Cuvier's measurements of the head of the Beluga, *D. leucas*. (Oss. Foss., v, p. 302.)

	Fossil.	*D. leucas.*
Length of the head from the occipital condyles to the end of the snout,	21·2 inches,	·532 m. = 20·9 inc.
" of one side of the lower jaw,	16 5 "	·408 " = 16·5 "
" of the alveolar margin, "	8·2 "	·198 " = 7·8 "
" of the symphysis "	3·1 "	·080 " = 3·1 "

From these measurements it might be inferred that the *fossil* and the *D. leucas* were identical in species, as well as in genus; but, at the same time, so many points of disagreement have been observed, as to render it highly probable that they are specifically different. In the number of teeth, they differ, as expressed below.

$$\text{Dental Formulæ} \quad \overset{\textit{Fossil.}}{\frac{8}{7}\,\frac{8}{7}=30}: \qquad \overset{\textit{D. leucas.}}{\frac{9}{9}\,\frac{9}{9}=36.}$$

They also differ much in the relative width of the maxillary and intermaxillary bones, as developed on the upper side of the snout, the intermaxillary being wider than the maxillary in Cuvier's figure, while in the fossil, the latter is twice the width of the former. The lines of the face appear also to be straighter, and the coronal process less elevated, making the upper portion of the head flatter in the *fossil* than in the *D. leucas.*

That this fossil cetacean belongs to the genus *Delphinus* of Linnæus, and to Lacepede's subgenus, *Delphinapterus*, I have little doubt; but, as already stated, it is highly probable that it belongs to a different species from Gmelin's *leucas*. I would, therefore, propose *Delphinus Vermontanus* for its provisional specific name, until its identity with the *D. leucas*, or some other known species, shall be established.

The locality, where these fossil bones were found, is situated a little more than one mile to the eastward of lake Champlain, and 60 feet above the mean level of the lake, as ascertained by the railroad survey. The mean height of the lake is 90 feet above the level of the sea, making the height of the point, where the fossils were imbedded, 150 feet above the sea. The geological formation, in which they were found, is very clearly characterized. It belongs to that portion of the Post-tertiary, which has sometimes been denominated the *Pleistocene* formation. This formation extends along the whole length of lake Champlain, and throughout the valley of the St. Lawrence. On the east side of the lake, in Vermont, it frequently attains a width of several miles, and, in places, exceeds 100 feet in depth. It consists, for the most part, of regularly stratified clay and sand, resting upon the Champlain rocks, or upon unstratified drift, and portions of it abound in marine bivalve fossil shells. These shells are of several species, nearly, or quite all of which are now found in a living state, on the Atlantic shores of New England: and it is common to find them with their valves united, with their epidermis undisturbed, and buried in such a position as to show, unequivocally, that they lived, propagated and died, in the places where they are found. The most abundant species is the *Sanguinolaria fusca.* The *Mya arenaria, Saxicava rugosa* and *Mytilus edulis* are quite common. Some other species are occasionally found.

The cut for the railroad, in which these fossil bones were obtained, is nearly half a mile in length, extending from north to south, and its greatest depth is about eighteen feet. The depth of the cut, at the place where the skeleton was found, is ten feet. About four feet of this depth, reckoning from the natural surface of the ground, consists of sand, showing no signs of stratification. Next below this is a mixture of sand and clay, which is regularly and distinctly stratified, for a depth of two and a half feet, below which is a vast bed of fine blue clay, in which I observed no signs of stratification, and which appears to have been, previous to the deposit of the sand and clay above it, a kind of quagmire. In the lower part of the stratified sand and clay, and nearly in contact with the upper surface of the blue clay, the shells of *Sanguinolaria fusca* and *Mytilus edulis* were exceedingly numerous. Below these, imbedded in the blue clay, were the *fossil bones.* The head of the skeleton was towards the northwest and lay lowest, while the body and tail extended towards the southeast. The highest part of the skeleton was about eighteen inches below the upper surface of the blue clay, or eight feet below the natural surface of the ground. In the clay, mingled with the bones, I found a number of specimens of *Saxicava rugosa* and two or three of *Nucula;* and I also found in it such indications of vegetable remains as to leave little doubt that this clay bed, once and for a long time, constituted a salt marsh, with rushes and grasses on the shore of the Pleistocene sea that then occupied the valley of lake Champlain.

Burlington, Vt., Jan. 1, 1850.

Art. XXIX.—*Abstract of a Meteorological Journal, kept at Marietta, Ohio, for the year* 1849, Lat. 39° 25′, Long. 4° 28′ west of Washington city; by S. P. Hildreth, M.D.

MONTHS.	THERMOMETER.			Fair days.	Cloudy days.	Rain and melted snow.	Prevailing winds.	BAROMETER.		
	Mean temperature.	Maximum.	Minimum.			In. and 100ths.		Maximum.	Minimum.	Range.
January, - -	30·46	59	6	9	22	4·09	W. & N. W.	30·10	29·25	·85
February, -	30·21	68	–2	12	16	2·58	W. S. W. & S. E.	29·85	29·20	·65
March, - -	45·04	72	21	14	17	4·37	S. S. W. & S. E.	29·60	28·88	·72
April, - -	50·57	84	21	20	10	2·50	S. W. & S. E.	29·60	28·95	·65
May, - -	61·40	86	38	20	11	5·92	S. & S. E.	29·70	29·10	·60
June, - -	71·33	89	50	21	9	4·42	S. & S. W.	29·65	29·20	·45
July, - -	72·20	89	48	25	6	1·21	S. & S. E.	29·70	29·30	·40
August, - -	69·61	86	52	22	9	3·50	S., N. & E.	29·50	29·15	·35
September, -	62·57	84	40	27	3	2·63	S., N. & S. E.	29·75	28·90	·85
October, - -	53·15	74	30	19	12	3·92	S. W. & W.	29·70	28·88	·82
November, -	47·25	78	20	25	5	2·58	S. S. E. & W.	29·58	29·10	·48
December, -	31·33	55	9	12	19	5·17	W., N. & S. E.	30·00	28·95	1·05
Mean for year,	52·09					43·18				

The mean temperature for the year 1849, is fifty-two degrees and nine hundredths, (52·09), being somewhat below the average temperature for this place, and was occasioned by the low grade of the summer months. It goes, however, to prove that the mean heat for this locality lies between fifty-two and fifty-three degrees of Fahrenheit.

The amount of rain and melted snow for the year is forty-two inches and eighty-nine hundredths, being over an inch less than in 1848, and ten inches less than in 1847. The rain has been very equally distributed through the year, affording an abundant supply for the crops generally, although some locations suffered from drought in July, injuring the corn crop considerably.

The past year has been marked by no great excesses in temperature. The cold in January and February, for a portion of the time, was quite severe; sinking the mercury on the 19th of the latter month, to two degrees below zero. It caused a great deal of floating ice in the Ohio river, so as to stop the progress of steamboats for a short time, but did not at any period freeze over the river so as to afford travellers a passage on the ice. The Muskingum from the slack-water improvements was closed for some weeks. The mean for the winter months is 34° 25′, being about two degrees less than that of 1848. Of snow, there fell about fourteen inches on six different periods; the largest amount at one time being six inches.

The mean of the spring months is 52° 33′; being rather below that of the previous year. Spring frosts continued to harass us as late as May, while on the 15th, 16th, and 17th of April, the frost was severe, sinking the temperature to 23°. It happened after a week of quite warm weather, and at a time when the pear, peach and plum were in bloom—killing nearly all these fruits. The apple did not bloom until the 27th of the month, but the germs were so much injured that the crop was almost entirely destroyed. One of the serious evils attached to our climate, is the frequent occurrence of late spring frosts at a time when fruit trees are most liable to injury. The beginning of May was marked by excessive rains, there falling nearly six inches during that month.

The mean temperature of the summer months is seventy-one degrees and five hundredths, which is about two degrees above that of 1848, and exactly that of 1846.

At two o'clock, on the morning of the 15th of June, a tremendous storm of electric fluid passed over this region, continuing for nearly two hours to discharge a continual stream of lightning, accompanied by terrific peals of thunder; several dwelling houses were struck, and trees demolished in the town. It ran along the telegraph wires into the office at Marietta, and ruined the magnetic machine. There fell two inches of rain, attended with little or no wind. The latter part of June was quite wet, rain falling almost daily, with a hot moist atmosphere, accompanied near the rivers with fogs. This state of the weather has been noticed by agriculturalists, as very injurious to the wheat crops, falling as it does at a time when the grain is forming, about the middle or last of June, producing a mildew or rust on the head and straw, and thus blighting the berry. The rust or blight this year prevailed throughout all the southern portions of Ohio, extending into Indiana and Illinois; while the northern districts of these states, being later in ripening, suffered but little. The color of this parasite was that of a bright iron rust, and so abundant that a cloud of dust arose from the straw as it fell before the progress of the reapers, covering the garments of the workmen with a red powder, as if colored by a dye. The same red fungus attacked the leaves of the common blackberry bushes, near the wheat, and was seen on the earth in divers places in the fields and in some gardens. Its effects were ruinous to the wheat crops, shrinking the grain in the most favored fields fifteen or twenty pounds in the bushel, destroying its farina so that merchantable flour could not be made from it, and causing a loss to the farming interest of several millions of dollars. Thousands of acres were entirely ruined and not harvested at all. Rye suffered more than wheat, being somewhat earlier in its growth. Grapes were attacked in the same manner, the mould on them being white, attaching itself to the stems, causing the fruit to blight and fall to the ground. Potatoes were generally good and free from "the rot." Indian corn was a fair yield, while the hay crop was never better. Our soil and climate are so constituted that if one of the staples fails, some other will supply its place; and it is not probable we shall suffer from famine, as they do in many parts of the earth.

The mean of the autumnal months is fifty-four degrees and thirty-two hundredths, being nearly five degrees warmer than that of 1848. Frost did not materially injure vegetation and garden plants until the first of November, when the cold destroyed the bloom of the Dahlia.

Floral Calendar.—March 7, White maple in bloom; 8th, Robin appears; 17, Hepatica triloba in bloom. Red elm, garden crocus.

April 4th, Apricot, Sanguinaria canadensis; 7th, Peach; 8th, Sugar tree quite green on side-hills; 11th, Green gage and cherry in bloom; 12, Pear; 15th, thermometer at 24° this morning, froze hard; 16th, thermometer 23°, some snow fell; the fruit blossoms to a large extent killed, and early garden vegetables; 25th, Tulip in bloom; 27th, Apple; Late cherry; 29th, Judas tree and Service berry.

May 1st, Ranunculus; 2d, Quince tree; 5th, Black haw; 7th, Cornus florida; 11th, Frost on fences back of town; 19th, frost on boards; 24th, Locust tree; 29th, Hudson strawberry ripe.

June 3d, Early peas fit for table; 15th, Russian cucumber, raised in open air; 19th, thermometer 121° in the sun's rays at 2 P. M.; 22d, the Rust noticed on the wheat, but began as early as the 15th in some places.

July 2d, Wheat harvest begins; 3d, Catalpa in bloom.

Marietta, January 23, 1850.

Art. XXX.—*Chemical Examinations of the Waters of some of the Mineral Springs of Canada;* by T. S. Hunt, Chemist and Mineralogist to the Geological Commission of Canada.

In the course of my official duties it has devolved upon me to examine the various mineral waters of the province and to submit the more important of them to accurate analyses. The first part of the results of these inquiries have already appeared in the Report of Progress for 1847, 1848, which was submitted to his excellency the Governor General on the 1st of May, 1849, from which I extract the analyses that follow. Some remarks as to the mode of collecting the waters may not be out of place here, as showing the precautions taken to prevent errors and to transport the waters unchanged to the place of analysis. Unless otherwise stated, they were always collected by myself from the spring, and put into large glass jars, holding about one hundred pounds; these were nearly filled, and being carefully stopped, the mouths were secured by a lute, which entirely excluded air and prevented the escape of gases. For the determination of the gases, the processes directed by Fresenius, in his admirable treatise, were employed; they consist in directly fixing upon the spot the carbonic acid gas by ammonio-chlorid of calcium, and the sulphuretted hydrogen by a solution of chlorid of arsenic. Carefully measured portions of the water being placed in bottles with these substances, the bottles were tightly sealed, and could thus be preserved until they were brought to the place of analysis.

In stating the composition of the waters, I shall first give the quantity of bases, acids and radicals in a thousand parts, and then in accordance with the general custom, shew how these may be united to form saline combinations; in following this course I have conformed to the general practice of chemists, rather because the results are more intelligible to the unscientific, and at the same time more readily compared with those of other analysts, than because the compounds thus calculated can be supposed to represent the real constitution of the water; for in the present state of our knowledge, we must, I think, be led to adopt the idea of a partition of bases among the different radicals, so that the bromine in a saline water instead of being, as it is here represented, in conformity with general custom, combined as a bromid of magnesium, is divided between the four metals usually present, in proportions which we have not yet the means of determining.

The analyses were performed upon weighed portions of water in preference to using measures; and the weights, including the specific gravities, were determined by a delicate balance made to order by Deleuil of Paris, and sensible to the demi-milligramme, when loaded with two hundred grammes.

The Caledonia Springs.—These springs which are well known as a place of resort during the warm season, are situated a few miles south of the Ottawa River, about forty miles from Montreal; the fountains which are four in number rise through strata of post-pliocene clay which overlie a rock equivalent to the Trenton limestone. Three of them, known as the Gas Spring, the Saline Spring, and the White Sulphur Spring, are situated within a distance of four or five rods, and the mouths of the latter two are not more than four feet apart. The fourth, known as the Intermitting Spring, is situated about two miles distant, and is much more saline than the others. The first three are alkaline, the sulphur spring strongly so, while the fourth contains in solution a great quantity of earthy chlorids.

None of these waters are what are called "acidulous saline," a character which is due to the presence of large quantities of carbonic acid, the quantity of this acid found, being in no case more than is required to form bicarbonates with the bases present.

I. *The Gas Spring.*—The waters of this spring were collected on the 27th of September, 1847. The temperature of the air being 61·7° Fahrenheit, that of the spring was 44·4. The discharge was ascertained by careful measurement to be four gallons per minute, a quantity which is little subject to variation. The water in the well is kept in constant agitation by the escape of carburetted hydrogen gas, which is evolved in considerable quantity. It was roughly estimated at the time, to be three hundred cubic inches a minute, but the discharge as I was informed, is often much more abundant.

The specific gravity of the water was found to be 1006·2. It is pleasantly saline to the taste, but not at all bitter; by exposure to the air it gradually deposits a white sediment of earthy carbonates. Its reaction is distinctly alkaline to test papers.

The examination of the unconcentrated water shewed the presence of chlorine, calcium and magnesium, but when the liquid is concentrated by boiling, these bases are wholly precipitated as carbonates, and the clear liquid is alkaline, yielding with a solution of chlorid of barium, a copious precipitate of carbonate which is dissolved by hydrochloric acid, leaving only a small quantity of sulphate of baryta. The alkaline liquid being evaporated to dryness, and the residue digested with alcohol, the solution gave evidence of the presence of both bromine and iodine; the saline residue was found to consist of salts of sodium with a small portion of chlorid of potassium. The precipitate of earthy carbonates contained traces of alumina, iron and manganese. On evaporating to dryness a quantity of the water with an acid, and treating the residue with water, a portion of silica was obtained.

The modes by which the quantities of chlorine, sulphuric acid, calcium, magnesium, sodium and potassium were obtained, need no particular description. The sketch of the plan of analyses here given, will be sufficient to show the processes adopted throughout the research, except that where the waters contained chlorids of calcium and magnesium, the amount of these bases was determined first upon one thousand grammes of the water evaporated with an acid, and then the same quantity having been boiled with the addition of distilled water until all the earthy salts were precipitated, the respective amounts of the calcium and magnesium, both in the precipitate and filtrate, were determined, and those in the latter, regarded as corresponding to the chlorids and sulphates of those bases, in the recent water. The alkalies were separated by successive treatment with baryta and carbonate of ammonia, and the amount of potassium in the mixed chlorids was then determined by converting them into the platino-chlorids, and separating the sodium salt by alcohol.

The bromine and iodine were determined by evaporating fifty pounds of the water to a small bulk, separating the earthy precipitate, and finally evaporating the residue to dryness. This was treated with alcohol of sp. gr. ·835 until all traces of iodids and bromids were removed. The alcoholic solution was then evaporated to dryness, and the treatment renewed with alcohol of ·820; this process was repeated a third time, having previously ignited the residue to destroy any organic matters, and the solution being again evaporated to dryness, was dissolved in water, and the amount of iodine determined after the admirable method of Lassaigne, which consists in precipitating it as an iodid of palladium. The bromids and chlorids remaining in the solution, were decomposed by a solution of nitrate of silver, and the mixed precipitate of chlorid and bromid of silver, after being fused and carefully weighed, was submitted in a state of fusion to the action of a current of dry chlorine gas, until the whole was converted into chlorid; from the loss, the amount of bromine was deduced by calculation.

The total amount of carbonic acid was determined by mixing measured portions of the water at the source, with caustic ammonia and a solution of chlorid of calcium; the proportion of carbonic acid in the precipitate thus obtained, was determined in the usual manner. The amount of carbonic acid required by those bases which were known to exist as carbonates in the water, was then deducted. The quantity of carbonate of soda was calculated from the excess of sodium over that required for the saturation of the chlorine, bromine, iodine and sulphuric acid, controlled by the amount of carbonate of baryta obtained by treating a solution of the solid residue of 1000 grammes of the water with chlorid of barium; the two results closely agreeing.

1000 parts of the water of the Gas Spring gave—

Chlorine,	4·242810
Bromine,	·011730
Iodine,	·000461
Sulphuric acid (SO^3),	·002400
Soda,	3·726400
Potash,	·022100
Lime,	·082880
Magnesia,	·254600
Alumina,	·004400
Silica,	·031000
Iron and manganese,	traces,
Carbonic acid,	·705000

These may be combined to form the following compounds—

Chlorid of sodium,	6·967500
" of potassium,	·030940

Bromid of sodium,	·015077
Iodid of sodium,	·000530
Sulphate of potash,	·005280
Carbonate of soda,	·048570
" of lime,	·148000
" of magnesia,	·526200
" of iron and manganese,	traces,
Alumina,	·004400
Silica,	·031000
Carbonic acid,	·349000
Water,	991·873503
	1000·000000

Saline ingredients in 1000 parts, 7·7775.

Carbonic acid in 100 cubic inches, 17·5.

II. *The Saline Spring.*—The spring thus named, is very similar to the last, but in reality less strongly saline. Its temperature was 45° F., that of the air being at the same time 60° F. The specific gravity 1005·824. Its reaction is more strongly alkaline, but otherwise the results of its qualitative examination are similar to those given under the head of the "Gas Spring." It contains no sulphuretted hydrogen whatever; some few bubbles of carburetted hydrogen are evolved, but the quantity is very small. The discharge from this spring is about ten gallons per minute.

1000 parts of the water gave—

Chlorine,	3·93830
Bromine,	·01317
Iodine,	·00123
Sulphuric acid (SO^3)	·00220
Soda,	3·52246
Potash,	·04100
Lime,	·06580
Magnesia,	·25020
Silica,	·04250
Alumina, iron and manganese,	traces,
Carbonic acid,	·64800

These may be combined in the following manner:—

Chlorid of sodium,	6·44090
" of potassium,	·02960
Bromid of sodium,	·01696
Iodid of sodium,	·00146
Sulphate of potash,	·00480
Cabonate of soda,	·17620
" of lime,	·11750
" of magnesia,	·51724

Carbonate of iron and manganese,	traces,
Alumina, ...	
Silica, ...	·04250
Carbonic acid, ...	·29200
Water, ...	992·36084
	1000·00000

The amount of solid matter in 1000 parts of the water is by calculation 7·347; experiment gave 7·280, which is a close approximation. The carbonate of magnesia loses a part of its carbonic acid during the evaporation, and exists in the residue as a basic carbonate; hence the slight deficiency in the result of experiment.

The quantity of carbonic acid, above what is represented as combined with the bases, equals 14·7 cubic inches in 100 cubic inches of the water.

III. *The Sulphur Spring.*—This spring is situated very near to the last; the openings of the two wells being not more than four feet apart. Although it bears the name of a sulphur water, its claim to that title is very small. It has a feebly sulphurous taste and odor, and darkens slightly salts of lead and silver, but the quantity of sulphur existing either as sulphuretted hydrogen or as alkaline sulphuret is very inconsiderable, and cannot be quantitatively estimated by the ordinary processes.

Several bottles of the water were mixed with a solution of arsenic at the spring, but the precipitate of sulphuret of arsenic was scarcely perceptible; the quantity of the sulphuretted hydrogen was not equal to a cubic inch to a gallon. It is still, however sufficient to impart medicinal powers to the water, for the efficacy of this spring over all the others in rheumatic and cutaneous affections is well attested. According to Dr. Stirling, who has been for many years a resident at the springs, and is a careful observer, the water was formerly much more sulphurous than at present; a thing not at all improbable, as it is well known that springs often change their character materially in the course of a few years.

The supply from this spring is apparently about the same as that of the "Gas Spring;" its waters flow into the same reservoir as those of the saline springs, and the two are used for hot baths. The mixture, after being heated for use, is without any odor of sulphur.

The temperature of the spring was found to be 46° F., that of the air being 60° F. The specific gravity of the water at 60° F. is 1003·7; its reaction is strongly alkaline, and the results of its qualitative examination show that it closely resembled the two preceding waters, except that only traces of iodine were detected in it.

1000 parts of the water of the sulphur spring gave:—

Chlorine,	2·12500
Bromine,	·00781
Iodine,	traces,
Sulphuric acid,	·01030
Potash,	·01450
Soda,	2·12370
Lime,	·11760
Magnesia,	·14230
Iron,	traces,
Alumina,	·00265
Silica,	·08400
Carbonic acid,	·59000

These combined in the usual manner, give as the composition of 1000 parts of the water:—

Chlorid of sodium,	3·84300
" of potassium,	·02300
Bromid of sodium,	·01004
Iodid of sodium,	traces,
Sulphate of soda,	·01833
Carbonate of soda,	·45580
" of lime,	·21000
" of magnesia,	·29400
" of iron,	traces,
Alumina,	·00265
Silica,	·08400
Carbonic acid,	·14100
Water,	994·91818
	1000·00000

The amount of solid matters in 1000 parts of the water is 4·9406.

The quantity of carbonic acid over that required to form neutral carbonates, would in a gaseous state equal 7·2 cubic inches in 100 of the water. The amount required to form the above carbonates is ·449, and an equal quantity of carbonic acid would be necessary to enable them to exist as bicarbonates, a condition in which these earthy bases are generally regarded as being dissolved in mineral waters. The whole of these alkaline waters have shown, it will be observed, a deficiency in the quantity of carbonic acid, and this is particularly marked in this last and most strongly alkaline of them all. This apparent difficulty is at once explained by the fact that the whole, or a part of the carbonate of magnesia, exists in the form of a double carbonate of soda and magnesia, a compound which is readily soluble in water and much more permanent than the bicarbonate

The large amount of silica which it contains, is an interesting peculiarity, and naturally connects itself with the strongly alkaline character of the water. As silica is capable of decomposing a solution of carbonate of soda, it is probable that a portion of the soda must really exist in the condition of a silicate. From the uncertainty which still remains as to the composition of these soluble silicates, it is impossible to calculate the portion of the soda which should be deducted from that represented as existing as carbonate, but an indirect experiment throws some light upon the question. 1000 grammes of the water were evaporated to perfect dryness, to render all the magnesia insoluble. The residue being then dissolved in distilled water, was mixed with a solution of chlorid of barium, and yielded a precipitate of carbonate, with a little sulphate, which contained an amount of carbonic acid corresponding to ·2540 of carbonate of soda, while the excess of soda above that required for saturating the chlorine, bromine and sulphuric acid, equalled ·4558 parts of carbonate. The difference ·2018 corresponds to ·1179 of pure soda, which may be regarded as forming a silicate with the ·0840 of silica. With our imperfect knowledge of silicates, especially the soluble ones, it is obviously useless to speculate farther upon the mode of combination in which these substances exist.*

IV. *The Intermitting Spring.*—This spring has been already described as situated about two miles distant from the others. It rises out of a bank of clay near the edge of a brook; a well has been sunk nearly thirty feet through the clay, and the water rises near to the surface. It is kept in almost constant agitation by the evolution of large quantities of carburetted hydrogen gas; the water from this cause, is kept constantly turbid by the quantity of clay diffused through it, and it is only after being allowed to stand for several hours in a quiet place, that it becomes transparent. The discharge of gas is not regular, some minutes often elapsing, during which only a few bubbles escape from time to time, after which a copious evolution occurs for a few moments, followed by another period of quiescence; from this peculiarity it is named the intermitting spring.

The temperature was found to be 50° F. at the bottom of the well; that of the air being 61°. The amount of water furnished by the spring could not be easily determined, as part of it escapes through the bank, but it is not large. At the time of my visit, the recent rains had diluted the spring with a good deal of surface water, and I accordingly availed myself of the politeness of the proprietor, Mr. Wilkinson, who allowed me to take as much as I required, from a supply which had been brought from the spring a month previous, and preserved in well covered puncheons.

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* Since my report was published, I find that Mr. O. Henry in his fine researches upon the sulphurous alkaline waters of the Pyrenees, has already shown that the soda generally regarded as existing in them as carbonate, is really in a great part in the form of a silicate, a similar conclusion to that which I have deduced from my examination of the sources of Caledonia. (See Journal de Pharm. et de Chim., t. vii., p. 15.

This was sensibly stronger to the taste than the water at the spring, and unlike the previously described waters, was disagreeably bitter, as well as saline. Its specific gravity was 1010·939.

A qualitative examination shewed the presence of chlorine, bromine and iodine, with potassium, sodium, calcium, and magnesium; a large portion of the latter two exist in the condition of chlorids. No sulphuric acid was detected; but traces of iron and alumina. Baryta, strontia, fluorine and phosphates were sought for; but with the exception of slight traces of the latter, the results were altogether negative.

1000 parts of the water of the Intermitting Spring afforded,

Chlorine	8·36979
Bromine	·02059
Iodine	·00187
Potash	·01930
Soda	6·49360
Lime	1·44930
Magnesia	·55467
Alumina and iron	traces.
Silica	·02250

These may be so combined as to give the following composition for 1000 parts of the water:—

Chlorid of sodium	12·250000
" of potassium	·030500
" of calcium	·287050
" of magnesium	1·033840
Bromid of magnesium	·023840
Iodid of magnesium	·002057
Carbonate of lime	·126460
" of magnesia	·863230
" of iron,	traces.
Alumina	
Silica	·022500
Carbonic acid	·501350
Water	984·859173
	1000·000000

The solid matter in 1000 parts, as determined by calculation, is 14·639 parts; the result obtained by directly evaporating a weighed quantity, and drying the residue at 300° F., was 14·500, the difference being probably due to a partial decomposition of the magnesian chlorid during the evaporation.

The carbonic acid of this water was not determined, as the fresh water, which was required for this purpose, was so much diluted as to be unlike the specimen analysed.

In a subsequent paper I purpose to describe some of the saline springs of the valley of the lower St. Lawrence, which are generally saline, and contain a greater or less proportion of earthy chlorids. The history of the mineral springs of the province when complete, will present some interesting relations to the geological structure of the country and the nature of the strata from which they rise.

Montreal, May 15, 1849.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Researches upon some derivatives of the Benzoic Series;* by G. Chancel, (Comptes Rend. des Travaux de Chimie, Juin, 1849, p. 177.) —The author has prepared the nitrobenzoic ethers of alcohol and wood-spirit, and confirmed their composition by analyses. He has found that they crystallize in right rhombic prisms of about 120°, and are consequently isomorphous. By the action of ammonia upon the vinic ether he obtained the nitrobenzamid which Mr. Field had before found by decomposing the nitrobenzoate of ammonia by heat. This body is sparingly soluble in water, above all in the cold, but dissolves readily in alcohol and ether, and crystallizes from them by slow evaporation in tables like gypsum. By a solution of potash it is decomposed with the evolution of ammonia, and yields nitrobenzoate of potash. When nitrobenzamid is dissolved in boiling water and hydrosulphuret of ammonia added in sufficient quantity, not the least trace of the amid separates on cooling. The liquid deposits a large amount of sulphur after standing a few hours, and by evaporation in a water bath to separate the last traces, the residue dissolved in water and filtered, gives by slow evaporation beautiful crystals which give on analysis the formula $C_7 H_{10} N_2 O_2$ (notation of Gerhardt). It loses an equivalent of water at 100° to 120° C., without undergoing any apparent alteration, so that its real formula, as is established by its compounds, is $C_7 H_8 N_2 O$.

This new substance no longer belongs to the benzoic series (C_7), but has disceded into the formic (C) and phenic (C_6) series, as will be seen by the results of its decomposition. It is a double carbonate of ammonia and aniline, *minus* the elements of two equivalents of water.

$$C H_2 O_2, C_6 H_7 N, H_3 N = C_7 H_8 N_2 O_2 + 2H_2 O.$$

The author has therefore called it *carbonilamid*. When gently heated with a mixture of lime and potash, it evolves in the form of ammonia exactly one half its nitrogren: if now the heat be considerably raised, pure aniline distils over and carbonate of potash remains. In the first stage of the process there is evidently the formation of a salt which if not an *anthranilate*, is isomeric with it and the true *carbonilate*, which is then by an elevation of temperature decomposed into a carbonate and aniline. The action of sulphuric acid is equally characteristic; sulphanilic acid and sulphate of ammonia are formed with the evolution of carbonic acid gas.

$$C_7 H_8 N_2 O + 2SH_2O_4 = CO_2 + C_6 H_7 N SO_3 + S(H, H_4 N) O_4$$

This body sustains a close relation to *urea* which is truly *carbamid;* carbonilamid is urea in which the residue of an equivalent of aniline replaces that of one of ammonia. To represent this by the abbreviated formulas of M. Laurent,

$$Am = (H_3 N + H) \qquad Am^{-2} = (H_3 N + H) - H_2$$

$$An = (C_6 H_7 N + H) \qquad An^{-2} = (C_6 H_7 N + H) - H_2$$

$$\text{Urea, (carbamid)} \ldots\ldots \; C\, Am^{-2}\, A^{-2}\, O = C_2 H_4 N_2 O$$

$$\text{Carbonilamid,} \ldots\ldots\ldots\ldots \; C\, An^{-2}\, Am^{-2}\, O = C_7 H_8 N_2 O$$

Like urea the new substance is readily soluble in water, alcohol and ether; the alcoholic solution decomposes spontaneously, but the watery solution gives fine colorless prisms of a fresh taste like nitre. The resemblance to urea is still farther shown by its action with acids, it is a veritable alkaloid and forms well defined crystalline salts. The nitrate, hydrochlorate and oxalate have been examined; the former is very sparingly soluble. It combines also with the nitrate of silver and the bichlorid of mercury; the chloroplatinate crystallizes in beautiful orange colored prisms. T. S. Hunt.

2. *On the Products of the dry distillation of Benzoate of Lime;* by G. Chancel, (Compt. Rend. des Trav. de Chim., March, 1849, p. 87.) —According to the researches of M. Peligot, the result of this distillation is a liquid, which he named benzone, and which corresponds to acetene, while carbonate of lime remains as a residue; he also recognized a portion of benzene and a hydrocarbon which he regarded as napthalene and which seemed to be secondary products of the decomposition.

But according to M. Chancel, the process is less simple and is always accompanied with the evolution of gaseous hydro-carburets during the whole process. When the dried salt is heated, the decomposition is complete at a temperature near low redness; along with the inflammable gases is obtained a brown liquid heavier than water. By distillation, a small quantity of benzene is separated; but the purification of the residue by this process was found impracticable. When submitted to the action of strong nitric acid, it evolves red vapors and ignites; if the action is now carried too far, a brown viscid mass results, insoluble in water; dissolved in a mixture of alcohol and ether and mixed with hydro-sulphuret of ammonia, the vessel after two or three days is found filled with magnificent golden yellow crystals. The same compound is obtained by dissolving the crude product of distillation in strong sulphuric acid, and after some days adding a little water until it becomes milky; the mixture on standing yields an abundant crust of this crystalline matter, which is even deposited in small quantities after a lapse of time from the crude liquid. It is consequently an original product of the decomposition of the benzoate; and its analysis, in whichever way obtained, gives numbers corresponding exactly to the formula $C_{13} H_{10} O$

(notation of Gerhardt), which is exactly the composition that theory assigns to benzone :—

$$2C_7H_5CaO_2=CO_2Ca_3+C_{13}H_{10}O.$$

Its claim to be considered as the acetonid of benzoic acid is shown by the fact that under the influence of potash-lime, it discedes at about 260° C. into benzoate of potash and pure benzene without evolving a trace of hydrogen gas or any other foreign substance.

$$C_{13}H_{10}O+KHO=C_7H_5KO_2+C_6H_6.$$

M. Chancel has given it the name of *benzophenone*, to show at once its relation to the benzoic and phenic series, while the termination recalls its place among the acetonids. It is insoluble in water but soluble in alcohol and ether; from a mixture of the two it is obtained by spontaneous evaporation in large transparent monoclinic prisms, of a slight amber tint. It fuses at 46° and boils at 315° C., distilling without alteration; its odor is fragrant, somewhat resembling benzoic ether.

Neither nitric nor sulphuric acids affect it in the cold; but fuming nitric acid by heat converts it into an oily liquid, which is dissolved by ether and deposited again almost immediately as a yellowish crystalline powder. This is *binitric benzophenone*, $C_{13}H_8(N_2O_4)O$ or $C_{13}H_8X2O$.

The product of the action of hydrosulphuret of ammonia upon this, is an alkaloid which had been some time before described by MM. Laurent and Chancel, under the name of *flarine*. The crude product of the distillation of the benzoate of lime, freed from benzene, was boiled several hours with fuming nitric acid and then diluted with water. The oily residue is mixed with ether, and after a time deposits a crystalline matter which was washed with a mixture of alcohol and ether. It is a mixture of binitric benzophenone, with some foreign matters which are very difficultly separable. By digestion in the cold with a mixture of hydrosulphuret of ammonia, alcohol and ether, the principal part is dissolved, and after twenty-four hours the vessel is filled with needles of the new alkaloid, which is purified by solution in hydrochloric acid, precipitation by ammonia and crystallization from alcohol. It forms fine needles, colorless or pale yellow, which are almost insoluble in water but dissolve in alcohol and ether. Fused with potash it disengages an oil possessing the properties of an alkaloid. Its formula is $C_{13}H_{12}N_2O$. Its salts are soluble and crystallizable; the chloroplatinate is $C_{13}H_{12}N_2O, 2(Cl\,HP \text{ and } Cl_2)$, a compound with two equivalents of the platinic chlorid.

These details respecting flavine are given in the Comptes Rendus des Trav. de Chimie for April, and the editors in a note announce that M. Chancel has found it to be in reality *carbanilid* or *anilic urea*. The details are promised in a following number. By referring to the account given above of carbanilamid by the same author, we shall see that while this is $C\,An^{-2}\,Am^{-2}\,O$, flavine is $C\,An^{-2}\,An^{-2}\,O=C_{13}H_{12}N_2O$; the former being the substance intermediate between flavine and urea. The alkaline product obtained by the action of potash upon this new alkaloid will then be no other than aniline.

Among the products found in the crude liquid which yields the benzophenone, are two solid carbonates of hydrogen isomeric with napthalene, one fusing at 92° and the other at 65° C.; the latter is obtained with benzonitryl when the vapor of benzoate of ammonia is passed over ignited caustic baryta.

M. Chancel refers to the analogy pointed out by Gerhardt between the ethers and the products of the action of the mineral acids upon hydrocarbons;* as between nitrobenzene and nitromethol, sulphobenzenic and sulphomethylic acids. He has extended this view still farther, and shows that as nitrobenzene contains the elements of nitric acid and benzene, minus $H_2 O$, so benzophenone is derived from the benzoic acid and benzene, minus the same elements. $C_7 H_6 O_2 + C_6 H_6 = C_{13} H_{10} O + H_2 O$. As the name of *phene* has already been given to benzene, which in reality does not belong to the benzoic series, M. Chancel observes that it will be well to apply to its derivatives the names of *nitrophenone* and *sulphophenone*, which will have the advantage of recalling their relations to benzophenone. T. S. H.

3. *On the Action of Nitric Acid upon Butyrone*, LAURENT and CHANCEL, (Compt. Rend. des Trav. de Chimie, 1848, p. 174.)—The acid obtained some years since by M. Chancel, by the action of nitric acid upon butyrone, and by him named butyronitric acid, has been submitted to a new examination, from which it results that its formula is $C_3 H_5 N O_4 = C_3 H_5 X O_2$; it is consequently *nitrometacetonic acid.* The normal acid being $C_3 H_6 O_2$. It is insoluble in, and more heavy than water; has a very sweet taste and an aromatic odor. Its salts are crystallizable and explode by heat; that of potash forms yellow scales like iodoform. T. S. H.

4. *On Sulphuretted Benzamid;* by A. CAHOURS, (Compt. Rend. des Trav. de Chim., Avril, 1849, de Comp. Rend. de l'Acad., t. xxvii, p.239.)—As the nitryls by fixing $H_2 O$ or $2H_2 O$ yield amids or ammoniacal salts, M. Cahours was desirous to determine whether from the analogy between water and sulphuretted hydrogen, it might be possible to produce the corresponding sulphuretted compounds. On dissolving benzonitryl in slightly ammoniacal alcohol and saturating with $H_2 S$, the solution became discolored, and after some time on concentrating by evaporation, a substance separated in yellow flakes, which dissolved in boiling water and crystallized by slow cooling in long sulphur-yellow needles of a satiny lustre. Analysis gave the formula $C_7 H_7 NS$, which represents sulphuretted benzamid. It is decomposed by red oxyd of mercury giving rise to water and sulphuret of mercury, and regenerating benzonitryl. Potassium decomposes it with the formation of a sulphuret and cyanid. M. Cahours proposes to pursue this interesting inquiry. T. S. H.

5. *On the Composition of Chloropicrine;* by A. CAHOURS, (Compt. Rend. des Trav. de Chimie, May, 1849, p. 171.)—In this Journal for May, 1849, p. 430, a new substance was described as discovered by Dr. Stenhouse by acting upon nitropicric acid by a solution of hypochlorite of lime. To this the discoverer assigned the formula $C_4 Cl_7 N_2 O_{10}$. As this seemed quite anomalous, I proposed in its place, assuming the quantities of carbon and chlorine found to be correct, $C_4 HCl_7 N_2 O_{10}$, and the more readily as his analysis actually gave a quantity of hydrogen amounting to one equivalent. M. Gerhardt remarking upon this

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* Precis de Chimie Organique, tom. 1er, p. 154. See also this Journal for July, 1849, p. 90.

substance (Compt. Rend. des Trav. de Chimie, Fevrier, p. 34), suggested that its real formula is $C Cl_3 NO_2$, (corresponding to $C_2 Cl_3 NO_4$ in the ordinary notation,) and that it is *nitric chloroform* $C Cl_3 X$. This formula which requires carbon 7·2, chlorine 65, and azote 8·4, has been verified by analyses made by M. Cahours upon a pure specimen of chloropicrine, which has given him carbon 7·09–7·19; chlorine 64·59. M. Gerhardt calls attention to the close resemblance between the properties of this compound and that obtained by Marignac in action with nitric acid upon the chlorid of napthalene, which he has described in his Precis, as *forméne, bichloro-binitrique*, and which is represented by $C Cl_2 N_2 O_4 = C Cl_2 X_2$. T. S. H.

6. *Process for the use of Tin Plate Scrap in the Manufacture of Malleable Iron;* patented by Ed. Schunck, (Chem. Gaz., Aug., 1849.)—Large quantities of tin plate scrap accumulate in the manufacture of tinman's ware; these and worn out articles of the same material are useless except for small articles which are sometimes made from them. Their employment in the manufacture of wrought iron has been prevented hitherto by the presence of the tin; the present process is proposed for its removal.

A hot solution of alkaline persulphuret, for instance, persulphuret of sodium, obtained by fusing sulphur with carbonate of soda, converts the tin into sulphuret which is retained in solution, leaving the iron perfectly free from tin.

The same end is attained, although in a less perfect manner, by a solution of oxyd of lead in caustic alkali, or by alkaline chromate in the caustic alkali. The former, however, produced a deposit of metallic lead, the latter of chromic oxyd, and the removal of either of these is attended with inconvenience; the first process is therefore preferred.

The tin is removed from the solution by evaporation and crystallization; the mass when drained and pressed is dried and roasted in a reverberatory furnace; carbonaceous matter with dry carbonate of soda or quicklime is then added and the tin reduced. The slag resulting from this process contains an alkaline sulphuret, to which more sulphur may be added to form again the solution for stripping the tin plate.

The iron scraps from which the tin has been removed are washed and packed into sheet iron cylinders, which are raised to a welding heat and brought under the hammer, as in the manufacture of other scrap iron. G. C. Schaeffer.

7. *Anisole, Salicylic Ether, and substances derived from them;* by A. Cahours, (Comptes Rendus, Mar. and May, 1849.)—This investigation is another result of the fine discovery of Zinin, that hydro-sulphate of ammonia is capable of transforming the nitric compounds into true organic bases. This process was at first applied almost exclusively to the nitric compounds of the hydrocarbons; but other facts show its extension to compounds originally containing oxygen. This remark applies to the researches before us. The value of this extension of the process of Zinin is not trifling when we consider that many of the more important organic bases contain oxygen; we are therefore nearer than ever to the fulfilment of the promise long since made, of the artificial formation of quinine, morphine, &c.

From the distillation of balsam of Tolu, Deville obtained a hydrocarbon $C_{14} H_8$, which has been named a toluole; it is a homologue of benzole. This substance furnished Drs. Muspratt and Hofmann by the process of Zinin, a new organic base, toluidine, a homologue of aniline. Their paper in the Lond. and Edin. Phil. Mag., Sept., 1845, well deserves reading, and is particularly valuable for a tabular view of the parallel anisic and phenic series. Most of the compounds in the anisic series had been discovered or investigated by M. Cahours; the present investigation fills many of the gaps by supplying homologues of the phenic series, and in some cases, furnishes compounds without a parallel in the latter series. Still more, in the paper above mentioned, Drs. Muspratt and Hofmann announce a new base, nitraniline, being aniline in which one equiv. of H_7 is replaced by NO_4—a most remarkable discovery, for the entrance of the elements of peroxyd of nitrogen without effect upon the basic properties of the original substance. We shall presently see that three new bases of this singular kind have been discovered, anisole, which bears the same relation to toluole that phenole does to benzole, has already furnished bi- and tri-nitric species, in which 2H and 3H are replaced by $2NO_4$ and $3NO_4$. By acting upon anisole with fuming nitric acid and keeping the mixture cold, M. Cahours has succeeded in forming the *mono-nitric anisole*—an amber colored, aromatic, heavy fluid, boiling at about 505° F. This substance is readily decomposed by an alcoholic solution of hydrosulphate of ammonia; sulphur is deposited and a new base, *anisidine*, is formed, $C_{14} H_9 NO_2$.

By a similar process, bi-nitric anisole furnishes a new base, differing from the last in having H replaced by NO_4, and is, notwithstanding the presence of the elements of a powerful acid, a true base capable of forming well defined crystalline salts with acids. *Nitric anisidine*, it may be called, $C_{14} H_8 N_2 O_6$, crystallizes in long reddish brown lustrous needles, insoluble in water, but readily soluble in boiling alcohol. Some of its salts are colorless when quite pure.

Fuming nitric acid forms with toluole a liquid mono-nitric, and a crystalline bi-nitric species. The former furnished with hydrosulphate of ammonia, toluidine, to Drs. Muspratt and Hofmann. The latter by the same reagent has given M. Cahours a new alkaloid, the *nitric toluidine*, $C_{14} H_8 N_2 O_4$, being toluidine with H replaced by NO_4.

Anisic acid with fuming nitric acid is found to form among other products, a new acid isomeric with tri-nitric anisole, and a homologue of picric acid. This substance, *chrysanisic acid*, $C_{14} H_5 N_3 O_{14}$, crystallizes from alcohol in beautiful golden yellow rhombohedral plates. It is distinguished from similar acids by giving a very soluble salt with potash.

The salycilic ether of wood-spirit (oil of wintergreen) forms a crystalline compound with bases, which furnishes on distillation, anisole. In like manner, Cahours has found that the salycilic ether of alcohol, forms crystalline compounds, and that of baryta on distillation gives a new substance, phenetole, $C_{16} H_{10} O_2$, a homologue of anisole. This, when acted upon by strong nitric acid, forms a binitric species, resembling binitric anisole, and probably also a trinitric species.

The alcoholic solution of the former with sulphuretted hydrogen and ammonia, forms *nitric phenetidine*, the homologue of nitric anisidine.

As the mono-nitric phenetole has not yet been obtained, we are without the original alkaloid phenetidine, of which the above is a derivative.

To render the relation of these remarkable substances more clear, we subjoin a table, containing also the previously known homologues.

I. Phenole	$C_{12}H_6O_2$
Nitrophenesic acid Bi-nitric phenole	$C_{12}\left\{\begin{matrix}H_4\\2NO_4\end{matrix}\right\}O_2$
Picric acid. Trinitric phenole	$C_{12}\left\{\begin{matrix}H_3\\3NO_4\end{matrix}\right\}O_2$
II. Anisole	$C_{14}H_8O_2$
Nitric anisole	$C_{14}\left\{\begin{matrix}H_7\\NO_4\end{matrix}\right\}O_2$
Bi-nitric	$C_{14}\left\{\begin{matrix}H_6\\2NO_4\end{matrix}\right\}O_2$
(Chrysanisic ac.) Tri-nitric anisole	$C_{14}\left\{\begin{matrix}H_5\\3NO_4\end{matrix}\right\}O_2$
Anisidine,	$C_{14}H_9NO_2$
Nitric anisidine	$C_{14}\left\{\begin{matrix}H_8\\NO_4\end{matrix}\right\}NO_2$
III. Phenetole	$C_{16}H_{10}O_2$
Bi-nitric phenetole	$C_{16}\left\{\begin{matrix}H_8\\2NO_4\end{matrix}\right\}O_2$
Tri-nitric phenetole	$C_{16}\left\{\begin{matrix}H_7\\3NO_4\end{matrix}\right\}O_2$
Phenetidine,	(wanting.)
Nitric phenetidine	$C_{14}\left\{\begin{matrix}H_{10}\\NO_4\end{matrix}\right\}NO_2$

IV. Benzole	$C_{12}H_6$	V. Toluole	$C_{14}H_8$
Aniline	$C_{12}H_7N$	Toluidine	$C_{14}H_9N$
Nitric aniline	$C_{12}\left\{\begin{matrix}H_6\\NO_4\end{matrix}\right\}N$	Nitric toluidine	$C_{14}\left\{\begin{matrix}H_8\\NO_4\end{matrix}\right\}N$

G. C. S.

8. *On the Compound Ammonias;* by Adolphe Wurtz, (Comptes Rendus, Aug., 1849.)—In the last number of this Journal (Jan., 1850, p. 65) Mr. Hunt has most clearly explained the mode of formation of this new alkaloid, and also their relation to a very interesting group of compounds. Since that paper was written, M. Wurtz has more fully described the properties of Methylamine and Ethylamine, and has also added a new ammonia to the series Valeramine.

Methylamine, as well as the other new alkaloid, may be obtained from its hydrochlorate by the action of zinc, just as ammonia is obtained from sal-ammoniac. Thus prepared, methylamine is a gas of ammoniacal odor, condensing into a liquid at about 32° F. Its density is a little greater than that of ammonia. It is the most soluble of all gases; at 53° F., one vol. of water dissolves 1040 vols.; at 77°, 959 vols.

In all its reactions, this substance can scarcely be distinguished from ammonia—it precipitates the same bases, e. g., magnesia, alumina, iron, lead, &c., and redissolves the same—zinc, copper and silver. The compound analogous to fulminating silver, however, does not detonate. Methylamine may be distinguished from ammonia by its burning with a yellowish flame. Its salts are generally soluble in absolute alcohol.

Ethylamine, by a freezing mixture is obtained as a caustic fluid, of ammoniacal odor, and boiling at 62° F. Its reactions are very similar to those of methylamine, but it does not form a precipitate with chlorid of platinum. It burns with a bluish flame.

Valeramine, the new alkaloid is obtained by the action of potash on cyanate of amylene (cyanic ether of fousel oil), the latter being prepared by distilling sulphamylate of potash in the cyanate of potash. Valeramine is a liquid with a burning bitter taste and ammoniacal odor; its solution in water produces the same reactions as above described, it redissolves the precipitate of salts of copper with more difficulty than the other ammonias; the same may be said of the solution of the chlorid of silver. The formula is $C_{10}H_{13}N$.

The strong resemblance of these new alkaloids to ammonia has undoubtedly caused their presence to be overlooked in many decompositions of nitrogenous substances. In a recent paper on the decomposition of caffeine by chlorine, Rochleder describes under the name of formyline, a new base to which is assigned the impossible formula C_2H_4N. This is undoubtedly methylamine, the analysis corresponding better with the composition of the latter substance, than with the above formula. Mr. Anderson has recently examined an alkaloid, petinine, $C_8H_{10}N$, which in all probability is butyramine. We have then the following homologous series.

Ammonia,	H_3N
Methylamine,	C_2H_5N
Ethylamine,	C_4H_7N
Butyramine,	$C_8H_{11}N$ (Petinine, *Anderson.*)
Valeramine,	$C_{10}H_{13}N$

9. *On a Copper Amalgam;* by Dr. PETTENKOFER, (Ann. der Chem. u. Pharm., June, 1849, in Chem. Gaz.)—This remarkable compound, used by dentists for filling teeth, contains 30 parts copper and 70 parts mercury. As found in the shops, it is so hard as to require a powerful blow with a hammer to break it; the texture is crystalline. When heated to near 600° F., it swells slightly, and after trituration in a mortar, it becomes so soft on cooling that it may be moulded in the fingers like clay. In a few hours it again becomes hard enough to cut bone. Its density in the two conditions is so nearly the same, that if pressed into a glass tube while in the soft state, it becomes an air-tight stopper when hard. Many useful and less hazardous applications than filling teeth may be made of this curious substance.

Of several modes of preparation, the following appears to be the easiest and best. Finely divided copper obtained by precipitation by iron, is triturated in a porcelain mortar with protoxyd of mercury, metallic mercury and boiling hot water. The mass from brittle becomes soft and plastic when enough mercury is taken up. The excess of mercury should be pressed out, and the cake allowed to harden, which takes more time, than after the second softening. G. C. S.

10. *Benzole;* by C. B. Mansfield, (Chem. Gaz., June, 1849.)—A useful application of coal naphtha, which is mainly benzole, was noticed in this Journal for June, 1849, p. 106. The author proposes a process for obtaining pure benzole in large quantities from coal tar. The light coal naphtha from coal tar, is to be distilled in a metallic retort or still, the head of which is surrounded by water—this rising to 212° and no higher, suffers the volatile substances of higher boiling point to fall back into the vessel, while the more volatile benzole passes over and is condensed as usual. By a second rectification, keeping the still head at a temperature of 176°, the benzole is obtained still purer. It is next agitated with one-tenth its bulk of strong nitric acid, poured off and again agitated with sulphuric acid. When redistilled, it may be further purified by cooling to 4° F.; the crystals pressed and afterwards treated with chlorid of calcium, furnish a pure article.

As benzole dissolves India rubber, gutta percha and most resins, it may be valuable for these purposes, for which, however, the crude coal naphtha is generally used. Its solvent power renders it, according to the author, a cheap and less volatile substitute for ether in the laboratory.

A large number of most interesting compounds, aniline, nitraniline, &c., may be obtained from this substance in great quantity, at but moderate cost. G. C. S.

11. *On the Separation of Phosphoric Acid from Alumina;* by H. Rose, (Bericht der K. P. Akad. Wissensch. zu Berlin, 1849, 220; Chem. Gaz., No. 173.)—The author recently published a method* upon separating phosphoric acid from bases by means of mercury, which admits of the phosphoric acid being separated from most of the bases in such a manner, that not only its quantity can be determined with great accuracy, but that after its separation the bases can be readily examined and accurately estimated, without being contaminated by the substance used for separating the phosphoric acid. The proposed method gave unsatisfactory results with the presence of peroxyd of iron and alumina. When iron alone is present, it requires but a slight modification; but with the presence of alumina the difficulties increase to such an extent that the method becomes inapplicable.

It is however often of importance to be able to determine the phosphoric acid with accuracy in complex compounds which also contain alumina. In several rocks, especially in the basalts, salts of phosphoric acid occur, principally apatite; and undoubtedly the great fertility of a soil consisting of decomposed basalt is owing to the admixture of apatite.

When basalt is treated in the pulverized state with a dilute acid, this dissolves the apatite, together with the constituents of the decomposed zeolitic mineral soluble in acids, among which alumina is almost always present. Now by means of the molybdate of ammonia, the acid solution can easily be tested for a small quantity of phosphoric acid, in order that when present, even in minute quantity, it may not be overlooked in the analysis.

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* See this Journal, viii, 181, Sept. 1849.

After numerous experiments, the author has found the following method to be the most advantageous for analyzing quantitatively complex phosphatic compounds containing alumina. The phosphate is dissolved in an acid, nitric or hydrochloric acid; and after dilution with water, a sufficient quantity of carbonate of baryta added. After it has stood for a couple of days in the cold, having been frequently agitated, it is filtered and the insoluble residue washed with cold water. The filtered solution contains the bases which were combined with the phosphoric acid, excepting alumina, peroxyd of iron and other weak bases. These, as well as the whole amount of phosphoric acid, are thus completely precipitated. The dissolved baryta is removed from the solution by sulphuric acid. This is somewhat difficult when much lime is present. In the filtered solution the bases are determined according to the usual methods.

The insoluble residue contains the whole amount of phosphoric acid which was present in the compound, as well as the alumina and the peroxyd of iron. It is dissolved in dilute hydrochloric acid, and the baryta removed by sulphuric acid. The filtered solution is saturated with carbonate of soda, and evaporated to dryness; the dry mass is mixed with silica and carbonate of soda, and heated to redness. The calcined mass is digested in water, and carbonate of ammonia added to it, when a considerable amount of silica is precipitated; it is filtered. The filtered liquid contains the whole of the phosphoric acid; it is supersaturated with hydrochloric acid, then with ammonia, and the phosphoric acid precipitated as ammonio-phosphate of magnesia.

The insoluble residue is digested with muriatic acid and the whole evaporated to dryness. The dry mass is humected with hydrochloric acid, and the silica separated in the usual manner, after which the alumina and peroxyd of iron are determined.

12. *On the Atomic Weight of Silica;* by H. Kopp, (Liebig's Ann., lxvii, p. 356; Chem. Gaz., July 16, 1849, p. 271.)—The doubts entertained respecting the atomic weight of silicon and the composition of silica according to one of the three formulæ SiO, SiO_2 or SiO_3, have not been solved by the views which have hitherto prevailed on this subject, where in general the decision has been made to depend on the circumstance, that a particular series of compounds might be most simply represented, sometimes according to one, sometimes according to the other formula. A peculiar mode of conceiving this subject shows that, admitting the correctness of the analytical results of Pelouze, the atomic weight of silicon with $H=1$ is 21·3, and the formula of silicic acid SiO_3.

Kopp has deduced this result from the difference between the boiling-points of the chlorid and bromid of silicon. The possibility is sufficiently evident of deciding the question by this means from a number of determinations of the differences between the boiling-points of several chlorids and bromids, in which the chlorine, on the one hand, may be regarded as a substitute for the bromine in the corresponding bromid, thereby establishing how many degrees the boiling-point rises or falls when, in any compound, chlorine is replaced by bromine, or *vice versâ*, bromine by chlorine. After determining the number of degrees which express this difference for the substitution of each atom of chlorine or bromine, it is possible, on the other hand, to conclude, from the difference between the boiling-points of a chlorid and the corresponding bromid, as to the number of atoms replaced. Now it results, from the comparison of the boiling-points of several bromids and chlorids, that the substitution of 1Cl by 1Br raises the boiling-point 32° Cent.; of 2Cl by 2Br, $2 \times 32 = 64°$; of 3Cl by 3B, $3 \times 32 = 96°$; while the boiling-point falls in the same proportion when, on the contrary, bromine is replaced by chlorine. Compare, for example, the boiling point of the following substances:—

		Boiling-point.
$C_4 H_5 Cl$	Chlorethyle, ...	+11°, Pierre.
$C_4 H_3 Cl$	Chloracetyle, ...	−18° to 15°, Regnault.
PCl_3	Chlorid of phosphorus . .	78°, Dumas, Pierre.

		Boiling-point found.	Calculated.
$C_4 H_5 Br$	Bromethyle	41° Pierre.	43°.
$C_4 H_3 Br$	Bromacetyle	Ord. temp.	14° to 17°.
PBr_3	Bromid of phosphorus . . .	175°, Pierre.	174°.

Several other comparisons enumerated by Kopp lead to the law above announced respecting the change in the boiling-point in substitutions of bromine and chlorine. It consequently follows, as above stated, that according as the boiling-point of a bromid, on comparison with that of its corresponding chlorid, is situated at 32, 64 or 96 degrees higher than in the chlorine compound, this latter must be regarded as containing 1, 2, 3 atoms of chlorine replaced by bromine. The boiling-points of the chlorid of silicon and of the bromid of silicon have been determined by Pierre, a most accurate observer, the first to be 59°, the latter to be 153°; the difference is 94°; whence it follows that in the bromid of silicon 3 atoms of bromine are substituted for 3 atoms of chlorine in the chlorid of silicon; that the first is $SiBr_3$, the latter $SiCl_3$, and that silica is therefore SiO_3; and consequently we must admit the atomic weight of silicon to be 21·3, H being assumed $=1$.

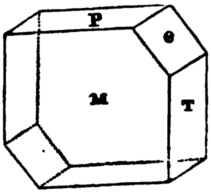
13. *On the Extraction of Mannite from the Dandelion;* by Messrs. SMITH; with an Analysis of the Mannite, by Dr. STENHOUSE. Communicated by Dr. GEORGE WILSON, (Proc. R. Soc. Edinb., ii, 223.)—Messrs. Smith stated that they had extracted from the dandelion, a large amount of a crystalline sweet substance, having all the physical characters of mannite. It was analysed by Dr. Stenhouse, and found to contain carbon, hydrogen, and oxygen, in the proportions which characterize the accepted formula for mannite; viz., $C_6 H_7 O_6$, so that it certainly was the substance it was supposed to be.

Messrs. Widumann and Frickhinger, it is stated, had anticipated Messrs. Smith in the separation of mannite from the dandelion juice, and were led to believe that the mannite did not preëxist ready formed in the dandelion; but was formed in the juice as the result of a peculiar fermentation which it underwent. This result was confirmed by the Messrs. Smith, who experimented with large parcels of the plant, and found that even from quantities of the fresh root, so large as 40 lbs., no mannite could be extracted, if the expressed juice were prevented from fermenting; whilst, if fermentation were permitted, the same weight of roots yielded a large quantity of mannite, which appears to be derived from the sugar, inulin, &c., of the dandelion, which was converted into mannite, gum, and lactic acid.

The Messrs. Smith stated, in conclusion, that they had not been able to confirm the statement of Polex, that the dandelion contains a bitter crystallizable substance, such as he had described under the name of taraxacine.

II. Mineralogy and Geology.

1. *On Danburite;* by J. D. Dana.—The species Danburite, from Danbury, Conn., has recently been found, through the explorations of Mr. G. J. Brush, in crystallized specimens, which have afforded the following crystallographic and chemical characters.



Triclinic; P : M = 110° and 70°; M : T = 54° and 126°; P : T = 93° nearly; P : e = 135°. Cleavage distinct parallel to M and P, less so parallel to T. Crystals imbedded in feldspar, associated with dolomite, and often an inch across. Occurs also disseminated massive without regular form. H. = 7 – 7·5. G. = 2·95, Silliman, Jr.; 2·97, Brush. Color pale yellow or whitish. Lustre vitreous. Translucent to subtranslucent. Exceedingly brittle. The mineral resembles chondrodite somewhat, but differs in form and in its distinct cleavage, as well as chemical characters.

The chemical examinations of the species have been made by Mr. H. Erni, in the Yale Laboratory, New Haven. Before the blowpipe it fuses rather easily, and in the dark it is seen to give the flame a green color, especially after having heated the mineral with sulphuric acid. With bisulphate of soda and fluor spar the green color (a color due to boracic acid) is as distinct and strong as with borax. With borax or soda, a transparent glassy globule is easily obtained. The amount of the mineral under examination was so small that the boracic acid could be estimated only from the loss. Mr. Erni obtained—

	I.	II.	Oxygen ratio for I.		
Silica,	49·74	49·71	25·84		12
Lime,	22·80	22·38	6·48	10·50	5
Magnesia,	1·98	1·30	0·78		
Soda,	9·82	....	2·51		
Potash,	4·31	....	0·73		
Perox. iron and Alumina,	2·11	1·65			
Boracic acid (loss),	9·24	....	6·35		3
	100 00				

The ratio gives the formula $\dot{R}\dddot{B}+4\dot{R}\dddot{Si}$. The alumina is probably due to some feldspar, which is often detected penetrating the crystals.

Prof. Shepard, who described the mineral in this Journal, vol. xxxv, p. 137, obtained for its composition,

$\dddot{Si}$ 56·00, $\dot{Ca}$ 28·33, $\overline{\dddot{Al}}$ 1·70, $\dot{Y}$? 0·85, $\dot{K}$ (with $\dot{Na}$?) and loss 5·12, $\dot{H}$ 8·0=100,

making it essentially a hydrous silicate of lime, a composition incompatible with the high degree of hardness. The presence of boracic acid accounts for this peculiarity.

2. *On the discovery of Sulphuret of Nickel in Northern New York;* by Dr. Franklin B. Hough, A.M., with additional observations by S. W. Johnson, (communicated for this Journal.)—In January of the present year, while visiting my friend Dr. Hough at his residence in Somerville, St. Lawrence Co., N. Y., he showed me specimens of a mineral which from its physical characters he had decided to be sulphuret of nickel.

As its existence in the United States has not been heretofore reported, I communicate the substance of a notice he furnished me, in his own words—"This mineral has been found in limited quantities at the Sterling iron mine, in Antwerp, Jefferson Co., N. Y. It was first noticed by the writer about two years since, and attracted his attention from its delicate capillary appearance, brilliant lustre, and the difference of its crystalline form from that of sulphuret of iron, which in color and association it so nearly resembles.

"It occurs mostly in radiating tufts of exceedingly minute and slender crystals of a brass-yellow color, and very brilliant lustre, which when highly magnified present the appearance of flattened hexagonal prisms with striated faces, the striæ being parallel with the principal faces of the prism.

"No cleavage was observed, nor could the terminal planes of the prisms (if they possess any) be determined. When moderately magnified, the minute acicular crystals appear to gradually narrow to a point, but lenses of a higher power disclose the fact that these needles are composed of several crystals of unequal length united by one or more of their lateral faces.

"They occur in geode-like cavities of the iron ore, which are lined with crystallizations of spathic iron, specular iron, quartz, calcite, cacoxene, and sulphuret of iron; from among these crystals the tufts proceed, attached generally to the spathic iron, more rarely to the crystals of iron. It is not an abundant mineral; only perhaps one or two dozen specimens have been procured since its discovery."

In one elegant specimen in Dr. Hough's cabinet, a cavity of more than half an inch in diameter is traversed by six or eight somewhat parallel crystals of larger size than any other yet procured. Their diameter is about $\frac{1}{60}$ of an inch. These are attached, as are all the few larger crystals, by both extremities.

In a specimen which the writer procured of a miner, several crystals $\frac{1}{2}$ inch in length and $\frac{1}{80}$ of an inch in diameter, extended from side to side of the cavity, being irregularly disposed, and firmly attached to the spathic iron at each end. Inspection of the sectional surface formed by the breaking of the geode, led to the observation of minute crystals apparently springing from the iron, and traversing the spathic iron. In two instances a crystal was found completely transfixing a rhomb of spathic iron, and supporting it in air, at a distance of $\frac{1}{8}$ inch above the inner surface of the cavity. In one of these cases, from the rhomb thus sustained, another needle of sulphuret of nickel projected upwards. These penetrating crystals are not in the least distorted. The larger ones of this specimen would admit of goniometrical measurement.

Chemical Examination.—A small fragment of one of the larger crystals heated in an open tube, evolved a strong odor of *sulphurous acid.* The roasted mineral which was black, but unaltered in form, was treated with hydrochloric acid, no action was manifest upon addition of nitric acid, and on application of heat, it quickly dissolved. The solution was evaporated to dryness, the residue dissolved and a drop of ferrocyanid of potassium added. The transparency of the solution was disturbed by a fine apparently white precipitate; an exactly similar result followed a parallel experiment, made upon a like quantity of a pure salt of nickel. This reaction is chiefly valuable as proving the absence of iron and copper.

A hot borax bead was brought in contact with a tuft of crystals. Some adhered. They melted in the oxydating flame, and dissolved in the borax, tinging it while hot, of a yellowish color, and upon cooling it appeared by reflected light, of a peculiar blackish shade, but colorless by transmitted light. In the reduction flame the glass after a time became gray and opaque. The blowpipe behavior of oxyd of nickel is differently stated in the books, but I have always observed the above phenomena with a certain rather slight degree of saturation.

The small quantity of mineral has precluded a more extended examination. Hereafter the associated specular iron, and spathic iron will be examined for nickel.

3. *New Mineral Localities in New York;* by Dr. F. B. Hough, (communicated for this Journal.)—*Pearl Spar*, has been discovered of a fine quality, in the town of Rossie, St. Lawrence county. It occurs in seams and crevices of white limestone, in a precipitous bank on the right side of the Oswegatchie river, and can be procured in considerable quantities.

Associated with this is calcareous spar, crystallized in the forms most common in the vicinity, viz., the scalene dodecahedron with the summits of the pyramids replaced by three rhombic faces. Another modification is common at this locality, in which the acute summit of the pyramids is replaced by a single hexagonal plane, perpendicular to the axis. The pearl spar is very white, and occurs crusting over the crystals of calcareous spar.

Idocrase, of a dark reddish brown color, and crystallized in the usual forms, occurs about a mile south of the village of Gouverneur, St. Lawrence county, in white limestone and associated with scapolite. The crystals attain a diameter of one or two inches, but the specimens which are best characterized are much smaller.

Sulphuret of copper, in limited quantities, has lately been discovered near Vrooman's Lake, in Antwerp, Jefferson county. Associated with this was fluor spar, and beautifully crystallized calcareous spar.

Sulphate of barytes, on the farm of Judge E. Dodge, in Gouverneur, St. Lawrence county, of a highly crystalline structure, and associated with fluor and calcareous spars. This locality is in the northwest part of the town, about four miles from the village, and has been known about two years, although no account of it has (to the writer's knowledge) ever been published. It appears to exist in great abundance, in veins in sandstone rock, and may hereafter become of economical importance. It breaks readily in the direction of the cleavage, and specimens which have been exposed to decay, present an appearance not unlike that of a mass of nails, which have been partially fused, and melted together. Color when recently broken, pure white.

The same mineral has been discovered on the farm of Mr. R. Dean, in Antwerp, Jefferson county, about one mile east of the village of Ox-Bow. It occupies cavities in a coarse half decayed white limestone, is of low specific gravity, in consequence of numerous vermicular cavities with which it abounds, and occasionally presents botryoidal surfaces, studded with crystalline faces. From the presence of iron pyrites in small quantities, it becomes quickly stained with oxyd of iron, when exposed to the weather.

Stalactitic quartz, has been found in limited quantities at a newly opened pit at the Parish iron mine, in the town of Rossie, St. Lawrence county. The same has been found at the Sterling iron mine, in Antwerp, Jefferson county, with the surfaces beautifully encrusted with cacoxenite.

4. *A list of the Minerals associated with the Emery of Asia Minor;* by J. LAWRENCE SMITH, (in a letter to one of the editors.)—Dr. Smith observes: I find associated with the emery,—calc spar; iron pyrites; octahedral and massive protoxyd of iron; magnetic iron ore; peroxyd of iron; hydrous peroxyd of iron; emerylite and other micas; sismondite or chloritoid (they evidently being the same mineral); diaspore; a mineral of waxy aspect having a similar composition to mica, being probably a kind of amorphous mica; a beautiful emerald green mineral, unalterable by heat and of considerable hardness, quantity in my possession too small to determine its character or composition; and black tourmaline. I do not allude here to the prismatic crystals of corundum, the massive blue corundum, as they properly constitute the emery.

5. *On the Degradation of the Rocks of New South Wales and Formation of Valleys,* (from the Geol. Rep. Exp. Exped., by J. D. DANA.)—The great depth, extent, and number of the valleys of New South Wales are calculated to excite wonder, and perplex us much in the study of their origin. In some of these sandstone regions, the gorges intersect the country in endless succession, with usually inaccessible precipices of one, two, or three thousand feet. They are deep gulfs, with walled sides composed of horizontal layers of sandstone. These layers seem once to have been continuous: and what is the force which has thus channelled the mountain structure? Are they "stupendous rents in the bosom of the earth?"* Are they regions of subsidence? Can it be that they were never filled, but were depressions left between the heaps of accumulating sediment that constitute the sandstone, which depressions were afterwards enlarged by the sea during the elevations of the land?† Or may we adopt the "preposter-

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* Strzelecki's New South Wales and Van Diemens Land, p. 57.

† Darwin's Volcanic Islands, p. 137.

ous" idea, that simple running water has been the agent; and if so, was it fresh water, or the ocean?

The forms of these valleys are as remarkable as their extent. Major Mitchell states that Cox's River rises in the Vale of Clywd, 2150 feet above the sea, and leaves this expanded basin through a gorge 2200 yards wide, flanked on each side by rocks of horizontally stratified sandstone eight hundred feet high: here it joins the Warragamba. Some of its tributaries rise at a height of 3500 feet above the sea, and the ravines they occupy cover an area of 1212 square miles. From this he calculates that *one hundred and thirty-four cubic miles* of stone have been removed from the valley of the Cox.* The facts observed by us are sufficient to substantiate the general result, although we cannot add definite estimates of our own. The Kangaroo Valley is another example of a valley, two to three miles in width, and a thousand feet to eighteen hundred deep, opening outward through a comparatively narrow gap: and by a rough calculation from our own examinations, and the map of Major Mitchell, the amount of rock necessary to fill the valley is equivalent to a rectangular ridge, twelve miles long, two miles wide, and two thousand feet high. On the map of the Illawarra District, the form of this valley, (from the colonial surveys,) may be seen; and it is interesting as an illustration of the general character of these sandstone gorges, though wider than many of them in proportion to its length. This is but a small example, however, compared with those of the interior. Mr. Darwin remarks upon this peculiarity of form,—their extent and width and many branches, yet narrow openings at their lower extremity; and he observes that the same is the character of the bays along the coast.

In studying the origin of these valleys, we have then to consider the following particulars:—

1. Their high, precipitous, or vertical walls of stratified sandstone, and their flat areas at bottom—excepting where the descent of the stream is rapid.
2. Their frequent great breadth towards their head, while below, they are often very narrow, like a large bay with a small entrance.
3. The absence of all traces of the fragmentary material which could have filled these valleys.

The idea that running water was the agent in these operations appears not so "preposterous" to us, as it is deemed by Mr. Darwin; and we think it may be shown that Major Mitchell was right in attributing the effects to this cause. The extent of the results is certainly no difficulty with one who admits time to be an element which a geologist has indefinitely at command. But the subject admits of full explanation, as we believe, without making any improbable supposition on this point. We need but refer to a former page, in which we have discussed the subject of valley-making by denudation among the Pacific islands,† to show that New Holland, after all, is not the most remarkable land in the world for valleys of denudation.

We should consider that the rock material is far more yielding than that of basaltic Tahiti. Indeed the whole rock, from the uppermost layer to the deposits below the coal, is remarkably fragile, considering the age of the deposits,—crumbling readily, and often breaking without difficulty in the fingers; and besides, it is much fissured. Even the harder fossiliferous Wollongong rock has been described as sometimes falling to pieces of itself when exposed to the air. Moreover there are occasional clayey or argillaceous layers which are still softer; and many of those of the coal formation are not firmer than the material of a common clay bank. The denudation of such material requires no preparatory decomposition, as with many igneous rocks, but takes place from wear alone, and with but slight force in the agent.

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* Expedition into Australia, ii. 352.

† See this volume, p. 48.

It is obvious for the same reason that the material carried off by denudation ought not to appear in fragments through the lower country. A short journey along a rapid stream would reduce even large masses to powder. The plains of the Kangaroo Valley are covered in places with basaltic pebbles or boulders; but the sandstone, which is the prevailing rock along the bed of the stream and in the enclosing hills, has scarcely a representative fragment among the debris. The sandstone blocks are worn to sand or earth by the torrent, while the harder basalt is slowly rounded. On the plains of Puenbuen, similar facts were apparent. The hills contain sandstone and basalt, but only the latter appears as boulders or pebbles over the plains, or along the streams below.

This Sydney sandstone does not even require running water to promote degradation. In many caverns along cliffs, the rock gradually falls to powder by a species of efflorescence. There are numerous instances of this along the coves of Port Jackson, where the crystallization of the saline spray reduces the rock to its original sand; and in the interior of the country there are large caves, formed apparently by this same process, though probably from the crystallization of nitrates. Near Puenbuen, these caves are from six to twenty feet deep, and from four to forty long. The roof is arched, and appears to be constantly crumbling, while the bottom is covered with a fine dry ash-like sand, into which the feet sink several inches. The same operation is going on along the summits of the Illawarra range; and one huge block was found so hollowed out in this way as to be a mere shell, which sounded under the hammer like a metallic vessel.

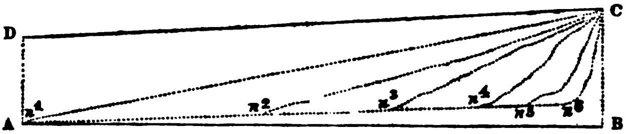
These various facts bring before us some idea of the yielding nature of the rock which the waters have to contend with in the denudation of this country, and they also illustrate the various processes at work. We allude to a single other mode of degradation before passing: it is the action of growing trees and their roots, both in opening fissures and tumbling blocks down the precipices. It is a cause influencing very decidedly the characters of cliffs, and at the same time preparing the rock for decomposition and wear.

The credibility of the view we favor is farther sustained by the character of the streams. We have alluded to the great extent of the floods, and the rapid rise of the rivers attending them. The stream of the Kangaroo Grounds, when visited by the writer, was a mere brook, fordable in any part, and it flowed along with quiet murmurings. How different when the brook becomes a river thirty feet deep, driving on in a broad torrent, and flooding the valley; and this had been its condition but a few weeks before. If, as has been shown, the transporting power of running water ***increases as the sixth power of the velocity***, and a stream of fifteen miles an hour has more than ten times the transporting power of one moving ten miles an hour, and more than a million that of a stream two miles an hour,* we can comprehend how very inadequate must be the conceptions of this force which we derive from viewing a stream at low water.

This rise in the Kangaroo Grounds is an index of what takes place every few years over the whole country. Our surprise at the amount of degradation subsides before such facts; and we rather wonder that sandstones so soft and fragile, which have been exposed probably from the Oolitic period, still cover the surface to so great an extent as they do at the present time.

Mr. Darwin derives his principal argument against the hypothesis of denudation from the forms of the valleys,—their width, extent and ramifications, and yet *narrow* embouchures. But we find on consideration that this form is a necessary result of the mode of denudation under the circumstances supposed.

In our account of the valleys of the Pacific islands,† it has been shown that the gorges change their character where the slopes become quite gradual, from a narrow defile with convergent sides, to a broad channel with vertical walls and flat bottom: the cause of this change has also been explained. The same cause should produce a like effect in Australia. Though it be a repetition, we add in this place a brief explanation of the process. A stream, in making a descent of two or three thousand feet from the higher summits to the level of the sea, gradually deepens its bed by wear. Since the waters are increasing in quantity from various sources as they flow onward, this deepening of the gorge should be most rapid at its lower extremity; and it would continue in progress until the bed in that part became so low or gradual in slope, that the waters had lost to a large degree their rending force, and any excavation at bottom was made up by the material deposited along its course. This fact determines a permanent height for the bottom of the lower valley. As the stream continues its wearing action, in the same manner, the lower valley is gradually prolonged upward, retaining nearly the same slope at bottom (one or two feet to the mile); consequently the steeper portion of the gorge is at the same rate becoming shorter and still steeper. Thus the head of the stream may finally become a series of cascades, or, as it happens at times in the Pacific, it may be reduced mostly to a single cascade of a thousand feet or more.



The progress of this change may be better understood from the cut here given.

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* Wm. Hopkins, *On the Transport of Erratic Blocks*, Trans. Camb. Phil. Soc., viii, 1844, p. 221.

† p. 379 of this Report; also this volume, p. 57.

A B C D is the rock to be cut through by the stream. Suppose denudation to produce first the course $C n^1$. The stream is filled, as is commonly the case, by lateral channels and rills down the sides of the gorge, as well as by the main source; and the amount or depth of water is thus in constant increase, as it flows onward. Denudation is consequently most rapid the farthest from the head, or towards n^1; the valley, therefore, increases in depth in this part till the slope has become so gentle here as to counterbalance the greater amount of water, at which point the bottom of the valley ceases to deepen; in this condition $n^1 n^2$ becomes the bottom of the lower valley, and Cn^2 the steeper portion above it. In the same manner the valley bottom continues to prolong at nearly the same slope, and Cn^3, Cn^4, Cn^5 become successively the course of the stream descending into it. And even Cn^6, is no exaggeration of possibilities; for many examples of it are met with.

But the results explained are but a part of the actual course of things in these regions of horizontally stratified rock. As on Oahu and elsewhere, when the denudation at bottom has reached its limit, the waters exert but little degrading power except during floods, and this takes place by the sides of the overflowing stream; at the same time, depositions of detritus take place along its banks. The result is that the rocks bounding the valley are worn away below, and are often undermined, as before explained; the valley widens at bottom to a flat plain, while the enclosing wall by the process becomes nearly vertical. A narrow riband of land between high precipices of rock is therefore a necessary result of the action.

Degradation still continues along the upper or steep part of the main stream, and also along the many streamlets and rills pouring down the valley's sides; and in each of these streamlets there is a tendency to produce below a flat-bottomed valley. The consequence is, that they increase the width and extent of the main valley-plain; for whenever they become thus flat-bottomed, they contribute to its lateral enlargement. At the same time, the bluffs at the lower extremity or embouchure of the main valley remain without much change, as the denudation is mostly confined to the vicinity of the streamlets alluded to, and these streamlets are most abundant above, since they are produced and fed chiefly by the rains in the higher part of the mountains. It is natural enough, therefore, that the valleys should not only become flat below and precipitous in their sides, but also that they should widen least at their lower extremity. We see, therefore, no necessity of appealing to any other cause than simply running water to account for the most stupendous results in Australia.

It has been supposed that the sea has been largely concerned in the denudation which has produced the Australian valleys. On this point enough, perhaps, has already been said on a former page. We find no reason for attributing any of the valleys to this source, although it is possible that some modifications may thus have resulted. The facts at Port Jackson are a sufficient reply on this point. The cliffs of the estuary actually undergo very little change from the action of its waters, and are far more altered by the mode of efflorescence described, and by rills of running water; and such action as is exerted, tends to remove the headlands instead of deepening the coves. There is, therefore, good reason for believing that such estuaries as Port Jackson and Macquarie were dug out by fresh waters, and have since been submerged. The fact that there is a correspondence in trend with the fissures of the sandstones, shows that their direction was determined by these fissures, or by faults which have the same origin. We have remarked that the rock has not the same dip in the two Heads of Port Jackson, a fact indicating the existence of one or more intermediate faults.

III. ZOOLOGY.

1. *Report on Zoophytes;* by JAMES D. DANA, Geologist of the Exploring Expedition under Captain Wilkes, U.S.N. 740 pp. 4to, 1846; with an Atlas of 61 plates in folio, mostly colored, 1849.—The publication of this work has been briefly announced in this Journal. The number of species of corals collected in the course of the voyage of the expedition was quite large, and it consequently became necessary to revise this department of science throughout; the volume therefore includes all known species of existing coral zoophytes, up to the date of its publication. The species added by Mr. Dana, or described anew from specimens examined, are in all cases indicated in connection with the mention of the locality; and moreover, in the catalogue of species accompanying the remarks upon each genus, the new and redescribed species are designated by an asterisk, in order that the observations for which the author is not personally responsible, may in all instances be readily obvious. The references and synonymes have been collected from a consultation and study of the original authors in this department, and not simply from the systematic treatises. There has thus been a complete revision of the synonymy of the science, besides a corrected identification of the species described or figured by former writers.

Out of the 444 known species of coral zoophytes, (excluding the Alcyonaria,) 233 are new species first described by the author; and of the remaining 211, 122 are redescribed from specimens. To the genus Madrepora, previously numbering 20 species, 52 new species are added, and 12 of the old species redescribed from specimens. The 30 known species of Astrææ were increased to 62; the four of Euphylliæ, D. (referred to Caryophyllia by Lamarck) to 15; the 17 of Fungidæ, to 60; the 57 of Madreporidæ to 141, and 34 out of the 57 old species were redescribed from specimens. This addition of species rendered it necessary to describe the old genera in some instances with more precision, and the examinations of the animals made it in general possible to give these descriptions a *zoological* character, a course in which Ehrenberg had led the way. Thus the science, like that of mollusca, is at last rescued from being a mere systematical arrangement of animal secretions. Species hardly distinguishable in the corals were sometimes found very different in the animals. The Antipathes, supposed hitherto to belong with the Gorgoniæ, from a resemblance in mode of growth, (as the species of each group have a horny axis,) were shown to be zoologically related to the Madreporæ,—the naked character of the tentacles and their number, *six*, being widely different from the same in the Gorgoniæ and other Alcyonaria, in which the tentacles are *fringed* with papillæ, and the number is *eight*. The Actiniæ usually separated widely from coral zoophytes, have received their true place, in close affiliation with the Astræidæ.

2. *A new genus of Orchestidæ;* by J. D. DANA.—In a synopsis of the genera of Gammaracea, in this Journal, volume viii, p. 135, three genera of Orchestidæ are mentioned, Talitrus, Orchestia and Allorchestes. We here add a fourth; and for the purpose of giving a fuller comparative view of the four, and correcting a misprinted word, we insert the generic characters for the group.

1. Pedes primi non cheliformes nec subcheliformes, articulo styliformi confecti; secundi sæpe subcheliformes, manu sive parvulâ et debili sive nullâ. Antennæ superiores basi inferiorum breviores.	*Talitrus* (Latreille).
2. *Talitro* pedes primos antennasque similis. Pedes *maris* secundi valde subcheliformes, manu grandi.	*Talitronus* (Dana).
3. Pedes primi secundique plus minusve subcheliformes. Antennæ superiores basi inferiorum breviores. Maxillipedes apicem obtusi.	*Orchestia* (Leach).
4. Pedes primi secundique plus minusve subcheliformes. Antennæ superiores breviores, basi inferiorum longiores. Maxillipedes apicem unguiculati.	*Allorchestes* (Dana).

3. *On the Genus Astræa;* by JAMES D. DANA.—In the Report on Zoophytes by the writer, the Genus Astræa has the same extent nearly that was given it by Lamarck, but based on zoological evidence. It includes all those species of Actinacea in which the budding is from the summit and is a consequence of the gradual widening of the summit by growth: in some the budding resulting in a subdivision of the disk of a polyp; and in others, in the development of a new polyp from the widening parts just exterior to the disk, the widening not extending to the disk. The latter division had previously been separated by Ehrenberg and united with some other species, including one or two Gemmiporæ, to form his genus Explanaria, a Lamarckian generic name but with a wholly new application.

The author has shown that the budding and growth of the Gemmiporæ is essentially different from that of the Astræoid species here alluded to—in the former, the buds being *lateral* from towards the base of the polyps, while in the latter (as in Astræas) the *summit* of the polyps gradually widens or extends and produces buds. The corals of this species show this difference in a striking manner.[*] Rejecting, therefore, the genus Explanaria, (a name objectionable on account of its double use, as well as its etymological incorrectness,) the author retained the Astræoid species in the genus Astræa and introduced the subdivisions, corresponding, of Orbicella[†] and Fissicella, the latter including the species which increase by a subdivision or fission of disks, and the former those whose buds were marginal or interstitial.

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[*] See this Journal [2], iii, 16, 18.

[†] Corresponds to Blainville's subdivision *Tubastræa*, a name of hybrid origin.

Professor Agassiz has made some recent observations on the ova and development of a species of Actinia, and has shown that the number of tentacles in the young animal is at first *five;* and he has consequently inferred that this is a typical or normal number for the true Actiniæ. The Actiniæ, it should be observed, are identical with the ordinary coral polyps in all points of structure, and this number should therefore be expected to occur among them.

But the author has elsewhere shown* that in the Orbicellæ the number of tentacles is a multiple of 6 or 4. In the *Orb. argus*, *glaucopis*, *curta*, the number is forty-eight; in the *coronata* and *rotulosa*, thirty-six; in the *pleiades*, *hyades*, *excelsa*, *annularis*, *stellulata*, *microphthalma*, *ocellina*, twenty-four; in the *stelligera*, eighteen. The number *six* is likewise characteristic (perhaps sometimes *four* and not *six*) of the species of the genus Caryophyllia and other Caryophyllidæ; also of the Madreporidæ in which the number is *twelve;* and of the Antipathidæ, in which it is *six.*

From these different observations we therefore seem to have two typical numbers in the same group of animals. Prof. Agassiz's observation is sustained by the fact that many Actiniæ have a five-lobed summit, or a five-lobed mouth.

It is therefore a very probable inference that those Astræidæ which bud by subdivision of the disk pertain to the five series, and owe to this in part the indefinite growth of the disk and multiplication of tentacles, and the consequent fission that takes place. While those of the six series, as far as direct observation has gone, have a fixed limit to the number of tentacles,—the even number *six* being a limit-number, while *five* may or may not be so. The multiplication of tentacles as growth proceeds, has been shown by the writer to be quite analogous to the spiral development of the leaves or petals of a plant; and it is therefore an interesting fact that *five* should be the number for the unlimited spiral, while *six* is a limited spiral. This is a point, however, which direct observation on the young of the fissiparous zoophytes alone can fully establish.

From this and other considerations, the author concludes that the two subgenera of Astrææ are much more widely separate than is admitted in his system, as published in his Report. The Actinaria appears to contain two grand groups, one characterized probably by the number *five*, and multiplication by fission, while the other is characterized by the number *six*, and an absence of fission. The former includes the *Actinidæ* (excluding the Orbicellæ, Echinoporæ, and Phyllastrææ), with the *Fungidæ;* while the latter embraces—1. the *Orbicellidæ* (the species of the three genera just mentioned); 2. the *Cyathophyllidæ;* 3. the *Caryophyllidæ;* 4. the *Gemmiporidæ;* 5. the *Zoanthidæ;* 6. the *Madreporidæ;* 7. the *Antipathidæ.*

The subgenus *Orbicella* should therefore take the rank of a genus. We shall probably find that there are Actiniæ of both kinds, although hitherto not distinguished.

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* See Report on Zoophytes, p. 49, and this Journal [2], iii, 9.

As far as the writer has observed, none of the Palæozoic corals, or Cyathophyllidæ, bud by subdivision of disks. Some species have summit or disk buds; but these buds *grow out from* the disk, like those which grow from the sides; and are not a consequence of a gradual and successive multiplication of the tentacles and widening of the original disk, ending in a progressive subdivision. The nearest representatives of the ancient Cyathophyllidæ are to be found in the Orbicellæ and Caryophylliæ. But the transverse horizontal septa of many of the ancient species have nothing corresponding in these groups though represented among the Pocilloporæ and some other genera of recent Madreporidæ.

IV. MISCELLANEOUS INTELLIGENCE.

1. *On the Extraction of Gold from the Copper Ores of Chessy and Sain-Bel;* by Messrs. ALLAIN and BARTENBACH, (Comptes Rendus, Nov. 19, 1849; Chem. Gaz., Jan. 1, 1850, p. 17.)—It results from our experiments, that at least two ten-thousandths of gold may be extracted from the above copper ores, the working of which, as the mines in question are of considerable extent, may become highly important. The density of the ore being 4, 1 cubic metre represents 800 grms. of gold. The operations are easy and rapid, and consist in first roasting the ore, and then dissolving out the gold.

After the mineral has been roasted in small fragments in the air, with a view to render it more friable, it is pulverized, passed through a fine brass sieve, and again roasted as much as possible, that is to say, until the powder has acquired a homogeneous brownish-red color. It is then formed into a paste with sulphuric acid of 66°, and roasted a last time until there is no further disengagement of sulphurous or sulphuric acid. The employment of sulphuric acid is most efficacious, as on the one hand, the sulphur in the form of sulphuric acid serves to remove sulphur, and on the other, as this metalloid, on becoming oxydized either by the air or at the expense of the oxygen of its compound, furnishes a greater amount of sulphuric acid than is wanted if the sulphurous vapors of the different roastings are passed into leaden chambers. Again, sulphuric acid is preferable for removing the oxyds of zinc and copper formed, as it readily converts the last traces of sulphurets which may have escaped the roasting into sulphates.

The substance is then reduced to as fine a powder as possible, and boiled with weak sulphuric acid. The insoluble portion is washed, and lastly heated with aqua regia diluted with water, but having been previously made in the proportion of 6 parts of hydrochloric acid of 21° and 1 part of nitric acid of 36°. This is an important point. The liquid containing the chlorids of iron, gold (and even of copper, for it is difficult to remove this metal entirely by a single ebullition with sulphuric acid), is placed in contact with iron, which precipitates the gold and copper; the precipitate is collected, washed, dried and calcined, to oxydize the copper. The gold may be separated from the oxyd of copper and oxyd of iron (for there is always a little of the latter precipitated in the cementation) by sulphuric or hydrochloric acid; but the separation, either by fusion or by chlorine or mercury, is preferable. With the chlorid the metal is reduced by heat, with amalgam the mercury is volatilized. The process above described is applicable to all pyrites which contain gold. The expenses attending the extraction of 2 lbs. of gold from the Chessy ores, after deducting the value of the copper obtained, do not exceed four hundred francs.

2. *The Table Land of Thibet*, (Athen., No. 1146.)—In April last we had occasion to speak of the first fruits of Dr. Hooker's mission to explore the botanical and physical character of the Himalaya. He had ascended the eastern extremity, within sight of the great snowy range, of which the peak Kinchin-junga, altitude 28,172 feet, is the loftiest yet known in the world,—and was anxiously waiting in the environs of Darjeeling, with the view of reaching the great table-land of Thibet, and determining the questions submitted to him by Humboldt relative to its elevation and snow lines.* Owing to the jealousy with which the frontiers are guarded by the Chinese and Sikkim tribes, and the difficulty of obtaining provisions and guides, it was some months before Dr. Hooker could make the pass. This, however, has been effected:—as the following letter describes.

Tungu, N.E. Sikkim, alt. 18,500 ft., July 25, 1849.

I have at length carried my point, and stood upon the table-land of Thibet, beyond the Sikkim frontier, at an elevation of 15,500 ft., at the back of the great range of snowy mountains. The pass is about ten miles north of this. We have Thibetan ponies, mounted thereon *à la Tartare;* but I walked a considerable part of the way, collecting many new plants. The Thibetans come over the frontier in summer to feed their Yaks, and reside in horse-hair tents. I entered one and was much amused with a fine Chinese-looking girl, a jolly laughing wench, who presented me with a slice of curd. These people eat curd with herbs, milk, and Fagopyrum bread—only the richer can afford to purchase rice. They have two sorts of churn: one is a goat-skin, in which the cream is enclosed and beaten, stamped upon and rolled; the other is an oblong box, a yard in length, full of rhododendron twigs, frosted with butter—and maggots. Some miles farther we reached the tents of Peppin, the Lachen Soubah, and were most graciously received by his squaw and family. The whole party squatted in a ring within the tent, myself seated at the head on a beautiful Chinese mat. The lady of the Soubah made tea, adding salt and butter, and each produced our Bhotea cup, which was always kept full. Curd, parched rice, and beaten maize were handed liberally round. Our fire was of juniper wood, and the utensils of clay, moulded at Dijarchi, except the bamboo churn, in which the tea, salt, and butter were churned previous to boiling. * * Presently a tremendous peal, like thunder, echoed down the glen. My companions started to their feet, and cried for me to be off,

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* "Que je suis heureux d'apprehendre [says Humboldt] que vous allez pénétrer dans ces belles vallées de l'Himalayah, et même au-delà vers Ladak et les plateaux de Thibet, dont la hauteur moyenne, non confondue avec celles des cîmes qui s'élèvent dans le plateau même, est un objet digne de recherche. * * Eclaircir le problème de la hauteur des neiges perpétuelles à la pente méridionale et à la pente septentrionale de l'Himalayah en vous rappellant les données que j'ai réunies dans le troisième volume de mon Asie Centrale."

—for the mountains were falling and a violent storm was at hand. We pursued our way for five or six miles in a thick fog; the roar of the falling masses from Kinchin-jow on the one hand and Chomoimo on the other being truly awful. Happily, no fragment can enter the valley, by reason of the low hills which flank the river along whose bed we were journeying. Violent rain ensued, and drenched us to the skin. Gradually, as we ascended, the valley widened; and at the altitude of about 15,000 feet we emerged into the broad, flat table-land, composed of range after range of inosculating stony terraces, with a little herbage, amongst which the Lachen river meanders. Five hundred feet farther we found ourselves at the top of a long flat ridge, connecting the north-west extreme of Kinchin-jow with Chomoimo,—and here stood the boundary mark. Happily, the weather cleared. Northward the plateau dipped by successive very low ridges, overhung with a canopy of the vapors that had deluged us. Easterly was the blue sky and low ridges of the lofty table-land, which here backs the great range. To the west the spurs of Chumoimo and much mist veiled the horizon. Southeast Kinchin-jow, a flat-topped mass of snow, altitude 20,000 feet, rose abruptly from rocky cliffs and piles of débris. Southwest was Chomoimo, equally snow; while southward, between these mountains, the plateau dipped into the funnel-mouth head of the Lachen valley. Here I had an opportunity of solving the great problem—the Elevatien of the Snow Line. Strange to say, there was not a particle of snow to be seen anywhere *en route*, right or left, nor on the great mountains for 1,500 feet above my position. The snow line in Sikkim lies on the Indian face of the Himalayan range, at below 15,000 feet,—on the Thibetan (northern) slope at above 16,000! I felt greatly delighted, and made a hasty sketch of the surrounding scenery:—somewhat rude, for at this great elevation my temples throb, and I retch with sickness.

Just above 15,000 feet all the plants are new; but the moment you reach the table-land nine-tenths of them disappear. Plants that are found at 12–13,000 feet on the Indian approaches to Thibet, did not ascend to the top of the Pass; still, as I always expected, at the turning point where the alpine Himalayan vegetation is to be soon replaced by Thibetan sterility, there is a sudden change in the *Flora*, and a development of species which are not found farther south, at equal altitudes in the Himalaya. We made a fire of Yak dung dried, and blew it up with bellows of goat skin, armed with a snout of Yak's horn. My poor Lepchas were benumbed with cold. I stayed an hour and a half on the Thibetan side of the frontier, and obtained good barometrical observations, and others with boiling water,—but the latter process is infinitely the more troublesome. On our return the weather cleared magnificently, and the views of the great mountains already named rising perpendicularly exceeded any that I ever beheld. For 6,000 feet they rise sheer up and loom through the mist overhead; their black wall-like faces patched with ice, and their tabular tops capped with a bed of green snow, probably from 200 to 300 feet thick. Southerly down the glen the mountains sunk to low hills, to rise again in the parallel of the great chain, twenty miles south, to perpetual snow, in rugged peaks. We stopped again at Peppin's tent for refreshment, and I again took horse. My stubborn, intractable, unshod Tartar pony never missed a foot. Sharp rocks, deep stony torrents, slippery paths, or pitch darkness, were all the same to him. These ponies are sorry looking beasts; but the Soubah, who weighs sixteen stone, rode his down the whole thirty miles of rocks, stones, streams, and mountains; and except to stop and shake themselves like a dog, with a violence that nearly unhorsed me, neither his steed nor mine exhibited any symptoms of fatigue. Fever rages below from Choontam to Darjeeling. My people behave admirably, and I never hear a complaint; but I find it very hard to see a poor fellow come in, his load left behind, staggering with fever, which he has caught by sleeping in the valleys, eyes sunk, temples throbbing, pulse at 120, and utterly disabled from calling up the merry smile with which the kind creatures always greet me. We have little rain, but much mist; and I find great difficulty in keeping my plants in order. Do not be alarmed for me about fever, for I shall not descend below 6,000 feet. I have not been below 10,000 feet for the last two months. I lead a hard, but healthy life; and know not what it is to spend a lonely-feeling hour, though without a soul to converse with. Arranging and labelling plants, and writing up my journal, are no trifling occupation, and I am incessantly at work. JOSEPH DALTON HOOKER.

3. *On the Classification of Colors.* Part II. By Professor J. D. FORBES, (Proc. R. Soc. Edinb., ii, 214.)—The object of this paper is chiefly one of nomenclature. Every one has felt the difficulty of describing with precision the innumerable hues which occur in nature and in art; and which it is equally desirable for the optical philosopher, the artist, and the manufacturer, to be able to refer to in a clear and definite manner. But such a nomenclature or classification must proceed upon some admission as to the manner of compounding complex hues out of simple ones; and, therefore, the author first treats of the (so-called) Primary Colors. He admits it as highly probable, that all known colors may be formed out of red, yellow, and blue; although, when we attempt to compound pigments, we have a very notable loss of light, and also an unavoidable impurity, which is most visible in the compound tints. The author, in passing, endeavors to explain clearly why the union of pigments never can produce a perfect white, although the colored light of the spectrum does so; for, by adding blue light to yellow light, we not only change the color, but we increase the illumination; whereas, by adding a blue to a yellow pigment, whilst we change the color, we at the same time reduce the luminousness of the surface, the blue particles being far less reflective than the yellow ones. Inferring from Newton's empirical rule, the quantities of red, yellow, and blue light, which should combine to make white light; and adopting Lambert's results as to the reflective powers of the brightest pigments, the author concludes, that the mean illumination of a disk put in rapid revolution, and containing colored sectors, will be 4·57 times *less* than if it reflected the whole incident light, or it will reflect only about *half* the light which white paper does under the same illumination, therefore it will appear relatively *grey* under any given external illumination.

The author then states, that the triangular arrangement of colors first proposed by Mayer, and farther carried out by Lambert, appears to afford the clearest and truest mode of displaying at a glance the modification of color due to the varying proportion of the three primary elements. In this triangle, perfect red, yellow, and blue, occupy the three corners; and these colors graduate into one another, according to the simple law of the distance of any point in the triangle from the three corners. The sides of the triangle are occupied by binary colors or compounds, by two and two; the interior is occupied by triple compounds; and the centre of gravity of the triangle ought to be a neutral grey.

Hence it will appear, that any hue not purposely diluted with black or white, is composed of a compound of a binary color with neutral gray. Hence a convenient nomenclature suggests itself as follows: the first column containing the binary colors.

RED.	Greyish Red.	Grey Red.	Red Grey.	Reddish Grey.	Grey.
Orangish Red,	*	*			
Red Orange,	*	*	*		
Reddish Orange,	*	*			
ORANGE.	Greyish Orange.	Grey Orange.	Orange Grey.	Orangish Grey.	Grey.
Yellowish Orange,	*	*			
Yellow Orange,	*	*	*		
Orangish Yellow,	*	*			
YELLOW.	Greyish Yellow.	Grey Yellow	Yellow Grey.	Yellowish Grey	Grey.
&c.	&c.	&c.	&c.	&c.	&c.

These colors are supposed to be of the standard or maximum attainable intensity.

They may be diluted with white on the one hand, forming *tints;* or with black, forming *shades.*

Mayer's triangle may be repeated with these modifications; but as the color tends to extinction, either in the direction of perfect blackness or perfect whiteness, the number of compartments in the triangles may be diminished as the dilution of the colors increases. Thus, the whole may be formed into a double pyramid of color, converging to white above and to black below.

The author has been much indebted to Mr. D. R. Hay, the ingenious author of the "Nomenclature of Colors," and other works, not only for specimens of colored papers formed by the actual mixture of the three primary colors, but also for many valuable suggestions, of which, in the course of this paper, he has freely availed himself.

It is the author's wish to be able to obtain a series of colored enamels complete, according to Mayer's and Lambert's classification. Some he has already obtained from the Vatican Collection, (of which he gives a short description,) and he hopes to render it more complete.

4. *New Process for extracting Sugar from the Sugar-cane;* by M. MELSENS, (Phil. Mag., xxxvi, 62, from Gard. Chron., Dec. 15, 1849.) —The following account of the new and important method of extracting sugar from the sugar-cane, is abridged from the first of two long articles recently published in the *Courier de l'Europe.*

The great difficulty which has been experienced up to the present time in the preparation of sugar, has been owing to the rapidity with which, when dissolved in water, it alters by exposure to the air in hot climates. It must, however, be obvious, since the cells of the sugar-cane are themselves full of sugar dissolved in water, and this solution can be kept for a long time in them, without undergoing any alteration at all, that if the same conditions which exist in nature could only be obtained in practice, there is no reason why an artificial solution of sugar may not be kept unaltered for a considerable space of time; or in other words, why water should not be used for the purpose of dissolving the sugar out of the crude juice expressed from the cane.

The difficulties, indeed, are not owing to the sugar or to the water, but to the air, and the ferments produced by its action on the crude sap of the sugar-cane. The object of M. Melsens was then, to exclude the air from the sap when extracted from the cane, and to prevent the formation of any ferments which might change the character of the saccharine matter. This he has succeeded in doing by availing himself of the well-known affinity of sulphurous acid for oxygen gas. Sulphurous acid, however, alone was found not to answer the purpose; the sulphuric acid, produced by the absorption of oxygen by sulphurous acid, acting on the sugar, converts it into grape-sugar. This difficulty has been overcome by using sulphurous acid combined with a powerful base, which, as the sulphurous acid is converted into sulphuric acid, combines with the latter and forms an insoluble salt.

The acid sulphites, and more especially the bisulphite of lime, were employed by M. Melsens for the double purpose of preventing fermentation by the action of the sulphurous acid, and of neutralizing the sulphuric acid as fast as it formed by means of the lime.

Sugar-candy dissolved in cold water containing bisulphite of lime, even in excess, crystallized entirely, and without undergoing any change, by spontaneous evaporation, at a low temperature. Several other experiments of the same nature, but differing in their details, always gave the same result; in each the sugar crystallized out by spontaneous evaporation, without any loss either in quantity or in quality, and without any appearance of molasses. In these experiments, the sugar dissolved in water, containing bisulphite of lime in excess, was boiled, and then left to evaporate, sometimes after being filtered, sometimes without any filtration at all.

From the experiments which M. Melsens has made with bisulphite of lime, it is probable that if a cold solution of this salt were to be poured on the sugar-cane grinder, so as to mix with the juice the moment it is expressed from the cane, the sugar might be kept for some time, and might be exposed to the heat necessary for its clarification without any sensible loss or deterioration.

But this same salt also possesses the property of coagulating, at a temperature of 212°, milk, white of egg, blood, and yolk of egg mixed with water. At a temperature of 212°, bisulphite of lime acts as a clarifier. It separates the albumen, caseine, and other similar azotized matters which are found in the sugar-cane. This separation is effected without appreciable loss in the quantity, or deterioration in the quality of the sugar.

Bisulphite of lime, moreover, rapidly and tolerably effectually bleaches the colored substances found in the sugar-cane; it prevents the formation of other colored matters produced by the action of air on the pulp of the cane; it also stops the production of those which are formed during evaporation, and above all, of those which require for their development the joint action of air and a free alkali.

It seems that colored substances which, under ordinary circumstances, are formed spontaneously by the exposure of the pulp of the sugar-cane to the air, never make their appearance when bisulphite of lime is employed. By evaporating at a low temperature, bisulphite of lime mixed with—1, a common solution of sugar; 2, the crude sap of the sugar-cane; 3, the juice of beet-root; no coloration was produced. By an evaporation of the same substances at a high temperature, the coloration was scarcely visible; indeed, with red beet-root the color was completely destroyed, and the sugar obtained was perfectly white.

It seems, then, that bisulphite of lime can be employed in the extraction of sugar:—1st, as an antiseptic, preventing the production and action of any ferment; 2nd, as a substance greedy of oxygen, opposing any alteration that might be caused by its action on the juice; 3rd, as a clarifier, coagulating at a temperature of 212° all albuminous and other coagulable matters; 4th, as a body bleaching all pre-existing colored products; 5th, as a body opposing itself in a very high degree to the formation of colored substances; 6th, as a base capable of neutralizing any hurtful acids which might exist or be formed in the juice, and substituting in their place a weak inactive acid, namely, sulphurous acid.

M. Melsens is of opinion that sugar can be obtained from the sugar-cane with no other source of heat than a tropical sun, excepting only for the purpose of clarification; indeed, the bisulphite of lime prevents the crude juice of the cane, or the syrup obtained therefrom, from undergoing any changes; great rapidity in the process of crystallization, indispensable at present, becomes by using this salt unnecessary; and more than this, the quantity of sugar which is now lost in the bagasse, in consequence of the impossibility of washing it out unchanged, can be all collected by being dissolved in water charged with bisulphite of lime.

The only objection that can be made to the above process is, that the sugar obtained by means of bisulphite of lime has a sulphurous taste; this is true, but the taste is completely lost—1st, by crushing the sugar and exposing it to the air, whereby the little sulphite of lime which there may be is converted into a tasteless sulphate; 2nd, by exposing the sugar to an atmosphere containing ammonia; if this is done the sugar acquires a very agreeable flavor of vanilla, but is apt to become a little discolored; 3rd, by clarifying it until it loses ten per cent. of its weight; by this process a pure white sugar can be obtained, which will bear comparison with any sample produced at present. The last is the process recommended to be used on a large scale. The quantity of sugar fit for the market which can be obtained from the sugar-cane by adopting bisulphite of lime, as above recommended, is at least double that obtained by the usual processes.

In consequence of M. Melsens having made all his experiments on the sugar-cane at Paris, and therefore on a small scale, he is not able to state how bisulphite of lime can best be used in the large colonial sugar manufactories, but is compelled to leave the application of the principles on which his method depends to the intelligence of the manufacturers themselves.

In the preparation of beet-root sugar bisulphite of lime is quite as useful as in the extraction of cane-sugar; the way in which it is to be employed in the former is fully explained in the second article published in the 507th number of the *Courier de l'Europe,* to which we must refer those among our readers who desire any further information on the subject.

5. *Anniversary of the Royal Society of London.*—On St. Andrew's Day, 30th of November, the anniversary of this Society was held at Somerset House, the Earl of Rosse, President, in the chair. An able review of the progress of astronomical and physical science was delivered by the President, the obituaries of deceased fellows read, and the three honorary rewards in the gift of the Society were publicly bestowed. The Copley Medal to Sir Roderick Murchison for his masterly works on the Silurian System and Geology of Russia; one of the Royal Medals to Col. Sabine for his valuable magnetic observations; and the other Royal Medal to Dr. Mantell, for the important services rendered to geology by his various memoirs on the Iguanodon, &c., published in the Philosophical Transactions. We have great pleasure in observing that the two Vice Presidents of the Geological Society of London, received this most honorable reward the scientific Englishman can attain, at the same time; the one for his eminence as a Geologist, and the other as a Paleontologist: both Sir G. Murchison and Dr. Mantell were also elected into the new council of the Royal Society.

6. *Ray Society*, (Athen., No. 1142.)—The Sixth Anniversary of the Ray Society was held during the meeting of the British Association, at Birmingham. From the Report of the Council it appears that the Society keeps up the number of its members. During the past year this body published a fourth part of the great work of Alder and Hancock on the Nudibranchiate Mollusca, a volume of the Correspondence of Ray, and the first volume of a complete Zoological Bibliography, by Prof. Agassiz, assisted by Mr. H. E. Strickland. For the present year a volume of Reports and Papers on Botany is already published; and two illustrated works are in a state of great forwardness: the first, a Monograph on the British Entomostracous Crustacea, by Dr. Baird of the British Museum; the second, a Memoir on the British Fresh-water Zoophytes, by Prof. Allman, of Dublin.

7. *Zoological Gardens*, *London*, (Athen.)—The total number of animals in the Zoological Gardens is 1352, of which 354 are mammalia, 853 birds, 145 reptiles. Sixty-five species were added during the past year. The total number of visitors for the year 1849 was 168,895, which is 25,265 more than in 1848, and 75,349 above the number in 1847.

8. *Mastodon angustidens.*—A nearly perfect specimen of this mastodon has been found about six leagues from Turin, in a bed of plastic clay containing fresh water shells and covered with sand. The skeleton is preserved in the Royal Museum at Turin and is one of the most perfect hitherto found in Europe.

9. *Development of Electricity by Muscular Contraction.*—The experiments of Du Bois Reymond have been repeated by Prof. Buff of Giessen with apparent success. In one trial, sixteen persons held each

other by moistened hands, and on all contracting simultaneously by the right, or the left arm, they formed as it were, a circuit of increased electromotive power. The effect on the needle was evident, and it was opposite according as the right or left arm was contracted: the direction of the current was always from the hand to the shoulder. It is essential that the muscular contraction should be increased or at least continued until the needle begins to return and then suddenly discontinued. The greatest deflection amounted to ten or twelve degrees.

10. *Influence of boracic acid in Vitrification*, (Comptes Rend., Oct. 22, 1849; Phil. Mag., Dec., 1849.)—MM. Maes and Clemandot have studied the effect of boracic acid in the manufacture of glass, and conclude that before long this material will be considered essential to the best glass for optical purposes. They have formed the glasses consisting of the borosilicate of potash and lime—of potash and zinc—of potash and barytes—of soda and zinc. These borosilicates are remarkable for their transparency and hardness.

OBITUARY.

11. Dr. Martin Gay, (in a letter to the Senior editor from Dr. C. T. Jackson, dated Boston, January 17th, 1850.)—It becomes my painful duty to announce to you the death of our much beloved friend, Dr. Martin Gay, who died of peritonitis on the 12th inst., at 1½ o'clock, P.M.

Dr. Gay was the eldest son of the late Hon. Ebenezer Gay, and was born in Boston on the 16th February, 1803, and at the time of his decease his age was 46 years, 10 months and 26 days.

He was educated at Harvard University. On leaving that Institution, he prosecuted his professional studies under the instruction of Dr. George C. Shattuck, an eminent practitioner in this city, and was graduated Doctor in Medicine on the 25th of August, 1826.

He was elected a Fellow of the American Academy of Arts and Sciences on the 14th of November, 1838.

In August, 1841, he received the degree of Master of Arts from Harvard University.

He was one of the original members of the Boston Society of Natural History, and filled successively the offices of Curator in Mineralogy and of Recording Secretary for several years.

In October, 1844, he was married to Miss Eleanor Allen, daughter of Frederic Allen, Esq., of Gardiner, Maine.

Dr. Gay was a successful practitioner of medicine, and occupied his leisure hours in chemical researches, and in the cultivation of the science of mineralogy. In analytic chemistry, especially in the department of medico-legal enquiry, he was regarded as one of our most faithful and accurate chemists.

His testimony in cases involving medico-chemical questions, was most implicitly relied upon in our courts of justice, and he was remarkable for the perspicuity and fairness of his evidence.

Devoted to the cultivation of science, he lost no opportunity for improving himself, and during his travels in Europe in 1842, he collected much valuable information and made the acquaintance of many distinguished chemists, mineralogists and geologists in France, Germany and Italy.

His moral character was held in the highest estimation by all who knew him. It was marked by integrity, kindness, courtesy, and a high sense of truth and honor.

His admiration of the true and beautiful in science, literature and the fine arts, was a distinguishing feature of his cultivated mind. Although naturally very amiable and mild in his manners, he was remarkable for his moral courage, and base or mean actions never failed to excite his indignation. Independent in his character, and relying on his own acute perceptions of truth, he cared little for the authority of others, when he was satisfied that they were in error.

As a physician he was beloved and respected by all who knew him, and his nice sense of professional honor, and his sincere regard for the rights of others, was well known and appreciated among his medical brethren. Our scientific friend is removed from among us, but he has left us a bright example in his pure and unspotted life, and in his noble devotion to the cause of science and of truth.

V. BIBLIOGRAPHY.

1. *Report of a Geological Reconnoissance of the Chippewa Land District of Wisconsin, and, incidentally, of a portion of the Kickapoo Country, and of a part of Iowa and of the Minesota Territory*, made under instructions from the United States Treasury Department; by DAVID DALE OWEN, M.D., U. S. Geologist for Wisconsin. 134 pp. 8vo, with numerous lithographs and geological sections.—This valuable document is occupied by the Reports of Dr. Owen, and his assistant, Mr. J. G. Norwood. The two regions particularly examined were first, along the Mississippi; and second, the interior and Lake Superior districts. The results, though only preliminary to a complete survey, are of great interest, both geologically and economically, as is true of whatever comes from the distinguished geologist whose name appears at the head of the survey. The illustrations of rock scenery, from Dr. Owen's sketches, are full of life and character. We cite the following facts.

The Kickapoo mines are situated between the Mississippi and Kickapoo and are connected with a magnesian limestone of the same character with that of the Mineral Point district. The ore is a peculiar one. It is of a light green color, waxy lustre and fracture, and very brittle, and is disseminated through ferruginous earthy matter composed chiefly of brown oxyd of iron. An analysis afforded protoxyd of copper 25·0, insoluble silicates with a trace of oxyd of iron 8·3, carbonic acid 5·0, water 11·2, peroxyd of iron 48·7, protoxyd of manganese 0·2, alumina 0·6, carbonate of lime 0·8=99·8. The position of the ore and rock indicates that it was once enclosed in a fissure in the magnesian limestone; but by decaying and denuding influences, the wall on one side has been removed. The ore is easily reduced and yields about twenty per cent. of copper.

With regard to the physical features of the country of the Lower Magnesian Limestone, Dr. Owen observes:—"The constant theme of remark, whilst travelling in the region of the upper Mississippi occupied by the lower magnesian limestone, was the picturesque character of the landscape, and especially the striking similarity which the rock exposure presents to that of ruined structures.

"The scenery on the Rhine, with its castellated heights, has been the frequent theme of remark and admiration by European travellers. Yet it is doubtful whether it is not equalled in actual beauty of landscape, by that of some of the streams that water this region of the far west. It is certain that though the rock formations essentially differ, nature has here fashioned, on an extensive scale, and in advance of all civilization, remarkable and curious counterparts to the artificial landscape which has given celebrity to that part of the European continent.

"The features of the scenery are not, indeed, of the loftiest and most impressive character. There are no elevated peaks, rising in majestic grandeur; no mountain torrents, shrouded in foam and chafing in their rocky channels; no deep and narrow valleys hemmed in on every side and forming, as it were, a little world of their own; no narrow and precipitous passes, winding through circuitous defiles; no cavernous gorges giving exit to pent up waters; no contorted and twisted strata, affording evidence of gigantic uplift and violent throes. But the features of the scene, though less grand and bold than those of mountainous regions, are yet impressive and strongly marked. We find the luxuriant sward, clothing the hill slope even down to the water's edge. We have the steep cliff shooting up through it, in mural escarpments. We have the stream, clear as crystal, now quiet and smooth and glassy, then ruffled by a temporary rapid, or when a terrace of rock abruptly crosses it, broken up into a small romantic cascade. We have clumps of trees, disposed with an effect that might baffle the landscape gardener, now crowning the grassy height, now dotting the green slope with partial and isolated shade. From the hill tops the intervening valleys wear the aspect of cultivated meadows and rich pasture grounds, irrigated by frequent rivulets that wend their way through fields of wild hay, fringed with flourishing willows. Here and there occupying its nook, on the bank of the stream, at some favorable spot, occurs the solitary wigwam, with its scanty appurtenances. On the summit levels spreads the wide prairie, decked with flowers of the gayest hue; its long undulating waves stretching away till sky and meadow mingle in the distant horizon. The whole combination suggests the idea, not of an aboriginal wilderness, inhabited by savage tribes, but of a country lately under a high state of cultivation and suddenly deserted by its inhabitants; their dwellings indeed gone, but the castle-homes of their chieftains only partially destroyed, and showing, in ruins, on the rocky summits around. This latter feature especially aids the delusion; for the peculiar aspect of the exposed limestone and its manner of weathering cause it to assume a resemblance somewhat fantastic indeed, but yet wonderfully close and faithful, to the dilapidated wall, with its crowning parapet and its projecting butresses and its flanking towers, and even the lesser details that mark the fortress of olden time.

"Bold exposures of rock, with a grassy bank beneath, such as are represented by the sketches, are, for the most part, only on the south and western sides of the hills; the northern and eastern declivities are more rounded and most generally overgrown with trees and shrubbery."

2. *The races of Man and their Geographical Distribution;* by CHARLES PICKERING, M.D., of the Scientific Corps of the Exploring

Expedition under C. Wilkes, U.S.N., Commander; forming volume IX. of the Reports of the Expedition. 450 pp. 4to.—This volume is the result of a vast amount of research by one peculiarly well fitted for observation by his habitual accuracy and his experience as a Naturalist. Dr. Pickering, after four years exploration in the Expedition around the world, made a journey to Egypt, Persia and Hindoostan to complete his observations. The range of the work will be gathered from the subjects of the chapters which we here mention. 1. On the Races of Man; 2. Explanation of the Map, illustrating their distribution; 3. the Races of America; 4. the Malayan Race, including the Polynesian; 5. the Australian Race; 6. the Papuan, including the Feejees; 7. the Negrillo Race of the East Indies, New Hebrides, &c.; 8. the Telingan or Indian Race in Hindoostan, &c.; 9. the Negro Race, Africa; 10. the Ethiopian Race, Nubia, &c.; 11. the Hottentot Race; 12. the Abyssinian Race; 13. the White or Arabian Race; 14. the Associations of the Races and Numerical Proportions; 15. Relations between the Races; 16. The Geographical Progress of Knowledge; 17, 18. Migrations by sea and by land; 19. Origin of Agriculture; 20. Zoological deductions; 21 to 24. Introduced Animals and Plants of America—of the Islands of the Pacific—of Equatorial Africa—of Southern Arabia; 25. Antiquities and introduced Plants and Animals of Hindoostan; 26. Introduced Plants and Animals of Egypt, enumerated in chronological order.—Dr. Pickering's extensive knowledge of botany and zoology has enabled him to collect together a vast amount of information in these closing chapters, and to correct or elucidate the meaning of many of the names of plants and animals in Greek and Arabic, which are often mistranslated in our Lexicons, and which in some cases were misunderstood by the translators of the Bible.

3. *Elements of Natural Philosophy*, designed as a Text-Book for Academies, High Schools and Colleges; by ALONZO GRAY, A.M., Prof. Chem. and Nat. Phil. in the Brooklyn Female Academy, and Author of Elements of Chemistry, &c. 406 pp. 12mo, with 360 wood-cuts. New York. Harper & Brothers. 1850.—The author of the work before us has prepared a very convenient and well arranged work on the different departments of Natural Philosophy. He has condensed a widely extended subject into a small compass well fitted for the student. The work commences with the general properties of matter, and the forces which govern it, and then passes to the subject of motion, the mechanical powers, hydrodynamics, pneumatics including meteorology, sound, heat, steam, electricity, galvanism, magnetism and light or optics. Galvanism is here in its right place with other branches of physics.

4. *Sailing Directions;* by Lieut. M. F. MAURY, U.S.N., National Observatory, Washington, published by authority of Commodore Lewis Warrington, Chief of the Bureau of Ordnance and Hydrography. 20 pp. 4to. Washington. 1850.—Lieut. Maury in this paper has made out a series of directions for navigating the different oceans, especially with regard to selecting the route for sailing. There are several tables containing specific information on this point for different latitudes and longitudes. These tables relate particularly to the route from New York to clear St. Roque, Brazil, and also to the routes to Europe and the return.

5. *The Plough, the Loom and the Anvil;* T. S. SKINNER, Editor.—This monthly periodical of practical and economical science, comes to us full of information and ably digested articles, original and selected. The first article in the January number before us, treats of the Harmony of Interests, Agricultural, Manufacturing and Commercial, in the United States, and is by H. C. Carey. It surveys the products of the country in these different departments with much valuable statistical detail, stating in tables the productions for successive years, of iron, coal, lead, woollens, &c., &c., and also illustrating the same by means of diagrams; and exhibiting a wide comprehension of the interests of the country in its various economical departments. Cotton Mills by Cotton Growers, Irish Peat, Charcoal and Sanitary Reform, are the subjects of other papers; and besides these, there are many shorter articles of practical value to the farmer and mechanic.

6. *Iconographic Encyclopædia of Science, Literature and Art*; by G. HECK, translated and edited by Prof. SPENCER F. BAIRD.—Rudolph Garrigue, New York.—The plates of Part V. of this Encyclopædia, the last which has reached us, are devoted to illustrations of the departments of Reptiles and Birds. The sketches are forcible and characteristic, illustrating the habits and haunts of the animals as well as their forms.

7. *Foster's Geological Chart.*—It has been represented to us that the Geological Chart noticed in our last number had not been finished,—although the copy received was varnished and mounted in the usual finished style; and that therefore it was not a fair subject for criticism. A revised copy, as now ready for publication, having the signatures of Professors E. Emmons and W. W. Mather has been shown us by the author. It has undergone important changes, though not all we should wish to see made. Figures of American fossils have been substituted to a considerable extent for foreign; misplaced fossils in the formations and the succession of rocks have been set right, and the names of the New York series of Rocks have been introduced,—together with the *Taconic formation* of Professor Emmons.

8. *The Annual of Scientific Discovery*, or Year Book of Facts in Science and Art, edited by DAVID A. WELLS, of the Lawrence Scientific School, Cambridge, and GEORGE BLISS, Jr.—We would call attention to the notice of this work on our advertising sheet. It is to be issued in the month of March, in a duodecimo volume of 350 pages. The Prospectus which has been sent us, bears high testimonials from Professors Agassiz, Horsford, Wyman and Gould, of Cambridge.

Agassiz's Lake Superior, is also soon to be issued, from the same house in Boston, and we doubt not it will be sought for with avidity. The high importance of the work, the peculiar interest of the region, and the eminent attainments of the author, must give these results of Prof. Agassiz and his able coadjutors a wide distribution over both this country and Europe.

9. *The Astronomical Journal*, Cambridge.—Nos. 3 and 4, for January 7, and February 2, 1850, contain—Observations of Metis, by *Mr. James Ferguson.*—Observations of Metis, made at the Hamburg Observatory, by *Prof. Charles Rümker.*—On the Phenomena attending the disappearance of the Rings of Saturn, by *G. P. Bond.*—On the

Heliocentric place of Neptune, by *George W. Coaklay.*—Note on the parallelogram of Forces, by *Prof. Peirce.*—On the orbit of the Great Comet of 1843, by *Prof. J. S. Hubbard*, (continued).—Development of the Perturbative Function of Planetary Motion, by *Prof. B. Peirce.*

10. *Journal of the Academy of Natural Sciences of Philadelphia.*—Part IV, which is just issued, completes the 1st volume of the new series in 4to, (pp. 356.) We give here the contents of the volume.

Part I. Dec. 1847.—1. ROBERT W. GIBBES, M.D., on the fossil genus Basilosaurus, Harlan, (Zeuglodon, Owen,) with a notice of specimens from the Eocene Green Sand of South Carolina.

2. M. TUOMEY, State Geologist of South Carolina.—Notice of the discovery of a Cranium of the Zeuglodon, (Basilosaurus.)

3. RICHARD OWEN, Esq., F.R.S.—Observations on certain fossil bones from the collection of the Academy of Natural Sciences of Philadelphia.

4. JOHN CASSIN.—Description of a new rapacious Bird in the Museum of the Academy of Natural Sciences of Philadelphia.

5. WILLIAM GAMBEL.—Remarks on the Birds observed in Upper California, with descriptions of New Species.

6. JOSEPH LEIDY, M.D.—(1.) History and Anatomy of the Hemipterous Genus Belostoma. (2.) Miscellanea Zoologica.

7. J. L. LE CONTE, M.D.—Fragmenta Entomologica.

Part II. August, 1848.—8. S. S. HALDEMAN.—Descriptions of North American Coleoptera, chiefly in the Cabinet of J. L. Le Conte, M.D., with reference to described species.

9. T. A. CONRAD.—Observations on the Eocene formation, and descriptions of one hundred and five new fossils of that period, from the vicinity of Vicksburg, Mississippi; with an Appendix.

10. JOHN CASSIN.—Description of a new *Buceros*, and a notice of the *Buceros elatus*, (Temm.,) both of which are in the collection of the Academy of Natural Sciences of Philadelphia.

11. JOHN CASSIN.—Descriptions of three new species of the genus *Icterus*, (Briss.,) specimens of which are in the Museum of the Academy of Natural Sciences of Philadelphia.

12. ROBERT W. GIBBES, M.D.—Monograph of the Fossil Squalidæ of the United States.

13. THOMAS NUTTAL.—Descriptions of Plants collected by William Gambel, M.D., in the Rocky Mountains and Upper California.

Part III. August, 1849. 14. ROBERT W. GIBBES.—Monograph of the Fossil Squalidæ of the United States.

15. T. A. CONRAD.—Descriptions of New Fossil and Recent Shells of the United States.

16. T. A. CONRAD.—Notes on Shells, with descriptions of new Genera and Species.

17. WILLIAM GAMBEL, M.D.—Remarks on the Birds of Upper California, with descriptions of new species.

18. SAMUEL GEORGE MORTON, M.D.—Additional Observations on a new living species of Hippopotamus.

19. JOHN CASSIN.—Descriptions of new species of Birds of the genera *Vidua*, Cuvier, *Euplectes*, Swainson, and *Pyrenestes*, Swainson,

specimens of which are in the collection of the Academy of Natural Sciences of Philadelphia.

20. S. S. HALDEMAN.—Cryptocephalinarum Boreali-americæ diagnoses cum speciebus novis musci lecontiani.

21. CHARLES D. MEIGS, M.D.—Observations on the Reproductive Organs, and on the Fœtus of the Delphinus Nesarnak.

Part IV. January, 1850. 22. T. A. CONRAD.—Description of new Fresh Water and Marine Shells.

23. SPENCER F. BAIRD, Carlisle, Pa.—Revision of the North American Tailed-Batrachia, with descriptions of new genera and species.

24. JOHN CASSIN.—Descriptions of new species of the Genera *Micrastur*, G. R. Gray, *Tanagra*, Linn., and *Sycobius*, Vieill.

25. ROBERT W. GIBBES, M.D.—New species of Myliobates from the Eocene of South Carolina, with other genera not heretofore observed in the United States.

26. JOSEPH LEIDY, M.D.—Descriptions of two species of Distoma, with the partial history of one of them.

27. JOHN L. LE CONTE, M.D.—An attempt to classify the Longicorn Coleoptera of the part of America north of Mexico.

11. *Memoirs of the American Academy of Arts and Sciences*, New Series, vol iv, Part I, 220 pp., 4to, with twenty-six plates. Cambridge. 1849. The following are the titles of the papers herein contained.

1. ASA GRAY, M.D.—Plantæ Fendlerianæ Novi-Mexicanæ: An Account of a Collection of plants made chiefly in the Vicinity of Santa Fé, New Mexico, by AUGUSTUS FENDLER; with Descriptions of the New Species, &c.

2. CHARLES HENRY DAVIS, A.M., U.S.N.—Upon the Geological Action of the Tidal and other Currents of the Ocean. (With three Plates.)

3. S. S. HALDEMAN, A.M.—History and Transformations of Corydalus cornutus. (With a Plate.)

4. JOSEPH LEIDY, M.D.—Internal Anatomy of Corydalus cornutus, in its three stages of existence. (With two Plates.)

5. WILLIAM S. SULLIVANT, A.M.—Contributions to the Bryology and Hepaticology of North America. Part II. (With five Plates.)

6. WILLIAM CRANCH BOND, A.M.—Description of the Observatory at Cambridge, Massachusetts. (With six Plates.)

7. GEORGE P. BOND.—On some Applications of the Method of Mechanical Quadratures.

8. JAMES DEANE, M.D.—Illustrations of Fossil Footprints of the Valley of the Connecticut. (With nine Plates.)

The plates are of the first order of excellence. Those illustrating the transformations and anatomy of the Corydalus cornutus are of unrivalled delicacy, and the dissections by Mr. Leidy, who is distinguished for his skill in microscopic anatomy, are no where surpassed. The plates of fossil footprints by Mr. Deane are in a good style of lithography, and accurately represent the character of the impressions. The author figures some new species but without giving names. The article is an interesting sequel, if we may so consider it, to Pres. Hitchcock's elaborate paper in the preceding volume.

12. *Boston Journal of Natural History*, Vol. VI, No. 1.—The following is a list of the memoirs in this number:

I. E. Desor. Embryology of Nemertes and Embryonic Development of Polynöe.

II. N. M. Hentz. Araneides of the United States, with figures.

III. J. D. Whitney. Chemical Examination of some Minerals.

IV. J. D. Whitney. Examination of the Arkansite, Schorlomite and Ozarkite of Shepard.

V. S. L. Bigelow, M.D. Habits of Salmo fontinalis.

VI. W. O. Ayres. Description of a new genus of Fishes, Malacosteus.

VII. J. L. Le Conte, M.D. On the Pselaphidæ of the United States.

VIII. Samuel Kneeland, Jr. Dissection of Crocodilus lucius.

IX. T. S. Hunt. Chemical examination of the new mineral Algerite, with a description by F. Alger.

X. F. Alger. Examination of a Sapphire from Cherokee Co., Georgia.

XI. Jeffries Wyman, M.D. On the Cancellated Structure of the Bones of the Human Body.

Smithsonian Contributions to Knowledge.—Occultations visible in the United States during the year 1850. Computed by John Downes. 26 pp. 4to. *Washington*, 1849.

Prof. Bell: A History of British Reptiles, 2nd edition, with 50 wood engravings. 8vo. *London*, 1849. 12*s.*

L. L. Boscawen Ibbetson: Notes on the Geology and Chemical Composition of the various strata of the Isle of Wight, with a map in relief colored geologically. 8vo. *London*, 1849. 7*s.* 6*d.*

Prof. Owen: On Parthenogenesis, or the Successive Production of Procreating Individuals from a single Ovum. 8vo. *London*, 1849. 5*s.*

A. E. Knox: Ornithological Rambles in Sussex, with 4 lithographs. Post 8vo. *London*, 1849. 7*s.* 6*d.*

E. Forbes and S. Hanley: A History of British Mollusca; parts 13 to 24. 8vo. *London*. 2*s.* 6*d.* plain; royal 8vo, colored, 5*s.*

H. Doubleday: A Synonymic list of British Lepidoptera. 8vo. *London*, 1849. 2*s.*

Quarterly Journal of the Geological Society.—No. 19 of this Journal is occupied with a memoir by Murchison on the Alps, Appennines and Carpathians, 160 pages. No 20, contains a memoir on the Eocene of Hampshire by Mr. Moore; on a Siliceous Zoophyte by Bowerbank; on Platysomus by P. Egerton; on Neritoma by Mr. Morris: on the Gypsum of Plaister Cove by Mr. Dawson; on Footprints in Sand by Lyell; on the Crag at Chillesford, by Mr. Prestwich; on Erect Sigillariæ, with drawings of the roots by Mr. Brown; on the Geology of Asia Minor by Mr. Hamilton; on Tylostoma by Mr. Sharpe; on Fossil Reptiles of New Jersey by Prof. Owen, with a translation of Bronn's Palæontological Statica.

Transactions of the Royal Society of Edinburgh, vol. xvi, Part V, 1848–1849. —Art. 34. Biographical Notice of the late Thomas Chalmers; *E. B. Ramsay.*—35. Theory of rolling Curves; *J. C. Maxwell.*—36. An account of Carnot's Theory of the Motive Power of Heat, with Numerical Results deduced from Regnault's Experiments on Steam; *W. Thomson.*—37. On the Effects of Pressure in lowering the freezing point of Water; *J. Thomson.*—38. On the gradual production of Luminous impressions on the Eye and other Phenomena of Vision; *W. Swan.*

Makerstoun Magnetical and Meteorological Observations for 1845 and 1846. 420 and lxxii pages, 4to, with numerous Charts; forming volume xix, part 1, of the Transactions of the Royal Society of Edinburgh. Edited by John Allan Brown, Esq., director of the Observatory of Edinburgh. 1849.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. XXXI.—*A brief Memoir of the late Walter Folger, of Nantucket;* by William Mitchell.

Among men of genius, those who have shared largely of nature's gifts, and manifested a high order of intellect in reference to those inquiries which are hidden from ordinary minds, the late Walter Folger of Nantucket, is entitled to a prominent rank. He was born in the 6th month, (June,) 1765. His father, also named Walter, was among the wealthier class of that day, and one of the first who engaged in the manufacture of sperm candles, since become so extensively the business of the place. He was descended from Peter Folger, one of the earlier settlers of the island, the maternal grandfather of Franklin, and the poet whose memory the Doctor so fondly cherished. Walter, senior, was much distinguished in early life for mechanical and mathematical talent, and at a later period when withdrawn from business, though eclipsed in every department by his son, he was sure to be found wherever any mechanical operation was in progress, that involved novelty of art or excellence of execution. On his mother's side the subject of this memoir was descended directly from Mary Starbuck, a matron of great notoriety in the history of the island; the first convert to the principles of the society of Friends, and the minister by whose influence so large a portion of those isolated people became members of that body of professing christians Of this distinguished lady, we find an account in the journal of a traveling minister of the society, who visited the island in the early part of the last century. "There was," says he, "on the island, one Nathaniel Starbuck, whose wife was a wise discreet woman, well read in scripture and not attached to any sect; but in great reputation throughout the island for knowledge in matters of religion, and an oracle among them on that account, insomuch that they would not do any thing without her advice and consent therein."

Although his family were numerous, the means of the father were quite adequate to furnish his son with liberal instruction; but education in that day, was but lightly esteemed by the islanders, a state of things forming a striking contrast with the agreeable circumstances of the present day, and his youth, with the exception of a few weeks occasionally spent in very indifferent schools, mostly taught by females, was suffered to pass away without that instruction which, with such materials to work upon, would have been of so much value to science.

In these schools he soon comprehended all that was taught, and spent most of his time in alternately assisting the pupils and instructing the teachers. The first study, in those branches in which he became distinguished, to which he directed his attention, was that of land surveying, in which, without the least personal assistance, he became exceedingly skillful. In the winter of 1782–3, he attended an evening school, in which he studied navigation and gauging, and readily acquainted himself with these branches. Nothing of a mathematical character seemed ever to present any difficulty to his mind. He mastered Algebra and Fluxions, without assistance, and while in his teens he read Euclid, as he would read a narrative, no problem arresting his progress; and yet so little did he know of language, or of any thing appertaining to it, that he had reached the years of manhood, as he often confessed, before he knew the definition of the word *grammar*. He afterwards accidentally met with an old volume of La Lande's large astronomical work, in the hands of a castaway sailor and purchased it, and to enable him to read it, he studied the French language, and with it the English, and was therefore able to read the French authors with ease. From this time he applied himself with great assiduity to the principal departments of physical science. As a practical mechanic and optician, he had few superiors, and in his own town certainly no equal. Every species of machinery on which he placed his eye, he seemed at once to comprehend. During most of the year 1783, he was afflicted with ill health, and much of the time confined to his bed begging constantly for books, which seemed the only needful opiate. There were few books at hand adapted to his taste; but his father finally succeeded in obtaining for him a work on Navigation, to which for the first time, was appended Dr. Maskelyne's method of obtaining the longitude at sea by means of lunar distances. This delighted him, and at the age of eighteen, prostrated with sickness, he familiarized himself with the problem, and the engagement so diverted his mind from his infirmities that he speedily regained his strength. He immediately applied all his influence to the encouragement of the use of this method among his fellow-townsmen, then universally engaged in the prosecution of whaling voyages. To numbers he gave personal instruction, and the first American ship-master who determined his longitude by lunar observations, is said to have been one of his pupils.

Soon after this period, he busied his mind in designing a clock, which, while answering the ordinary purposes of time-keeping, should exhibit various phenomena connected with the solar and lunar motions. Having completed the plan, he submitted it to his father, for whose judgment in mechanics he had the highest regard, and receiving his sanction, he commenced the work at the age of twenty-two, and devoting only his leisure amid other engagements, finished it in the course of the second year. This clock now stands in the family parlor a monument of mechanical ingenuity;—brown with age and now somewhat antiquated in its appearance, it is still a wonder. Nothing but the glass which covers its face, owes its construction to another hand, and its mechanical execution would be creditable to a professed workman. But its chief excellence is in the phenomena which it exhibits. The diurnal motion of the sun is represented by a circular metallic plate, so adjusted that it is seen through a slit in the dial plate, at a greater or less meridian altitude, as the declination changes; rising and setting as in nature, and changing the time in conformity to the latitude, change of declination and equation on each day, giving also through the entire day, the time of his rising and setting and place in the ecliptic. The moon is represented by a spherule exhibited to the eye in the same manner; but by having one hemisphere colored, and by a process much more complicated, shows with great faithfulness, not only the rising, setting and southing of the moon, with the time of full sea at Nantucket; but also the chief phenomena dependent on the obliquity of the moon's path to the ecliptic, and the revolution of her nodes, such as the hunter's and harvest moon, &c. Some of these involve a motion of the works through a period of eighteen years and two hundred and twenty-five days, and the wheel by which the date of the year is advertised is so constructed, that its revolution is only completed in one hundred years, though necessarily suspended ten years of that period.

For the year 1790, he made the necessary calculations and published an almanac; he had prepared also the ephemeris of 1791, with some very curious calculations on the annular eclipse of that year, the formation of the ring occurring precisely at sunrise; but these he never published.

In concert with several observers on the continent, among whom were Bowditch and Jefferson, he made special preparation, to observe the beginning and end of the solar eclipse of 1806, total in Boston and nearly so at Nantucket. The day was cloudless and the results satisfactory.

Probably the most valuable observations that he ever made were those on the comet of 1807—the first comet he had ever seen. On the first appearance of this body, he commenced taking a series of angular distances to the various fixed stars near which it passed. Then angles were taken with a sextant, in the use of which he was very skillful. Having been in the habit for many years of adjusting this instrument for the seamen of his native town, no one could use it more dexterously. His application to this work, as to every undertaking, was unremitting; he followed it through the whole period of its visibility, and in the latter part of autumn, while the comet was circumpolar, by obtaining angles through the whole night above and below the pole, he was able to detect its parallax, as well as its motion and position.

These observations were never published, and it now may be well doubted whether a vestige of his notes remain, the labor having been performed chiefly for his own gratification. The great comet of 1811 did not escape his attention, and his observations met with a better fate. He was induced to publish them in detail, and they were so numerous that the angles alone, when reduced, occupied an entire page of a Boston newspaper. With his expertness in the use of the sextant, and the sharp nucleus of that beautiful comet, his results were exceedingly accurate, and were so esteemed by Dr. Bowditch who used them in calculating its elements.

In earlier life he had constructed a number of small telescopes; but at the age of fifty-four he undertook the construction of a reflector of considerable size, and finished it in the succeeding year. This telescope is a Gregorian, the larger speculum is five inches, and the smaller, one inch in diameter. Its focal length is five feet, with one eye-piece magnifying not less than three hundred. It is not mounted equatorially, nor has it any arrangement for measures; but it is furnished with rack work for slow azimuth and altitude movement. The stand is of oak and has four legs on the plan recommended by the elder Tulley, and it is exceedingly steady—illustrating the advantage of this method for firmness no less than safety. The tube is of sheet iron and very neatly finished. The stand, which was made by his son, is the only part which was not formed by his own hands. In grinding the large speculum he dispensed entirely with the bed of hones, using the grinding powder after it was worn very fine on the pewter tool. In reference to its figure, there is doubt whether its curve is parabolic. He objected to that form and demonstrated that it is not the best except for objects whose distance is infinite. When the specula were finished, they were placed for trial in a rude tube of deal board mounted on a temporary support and directed to the planet Jupiter; and whatever may have been its subsequent performances, which were certainly no better than what might have been anticipated,—in this first trial its performance was astonishing. For light, distinctness of vision, and clearness of outline, it is scarcely surpassed by the larger and far more expensive instruments of the present day. While in this tube and with this temporary adjustment, he viewed the moon under favorable circumstances of weather, three days after the change, and detected that delicate thread of corpuscular light which was seen by Schröter in the early part of the year 1792 with a reflector of nearly the same size, and he described it almost in the words of the German astronomer, though he had never seen the paper of Schröter and knew nothing of the discovery. When the telescope was completed and mounted, his neighbors thronged his house to obtain a sight of the moon or other celestial objects, and although a severe tax upon him, he at all times gratified their wishes with the most enduring patience.

On the occasion of the return of the Encke comet in 1829, when the theory of Encke was so strikingly verified, he became interested in the subject of a resisting medium, and for his own satisfaction constructed a set of tables for the determination of the place of the comet for any period past or future within the limit of a thousand years. The labor in the construction of these tables was immense; but with his usual untiring zeal and application, he accomplished it, before the comet was beyond the reach of the telescope. The figures made in this work were so numerous that he often exhibited the sheets containing the rough computations as a curiosity. These tables he always declined publishing though often solicited to do so, and they remain to this day among the fragments of his industry.

He kept for many years a meteorological journal, using a barometer and thermometer of his own construction, both of which were remarkable for their accuracy. Indeed he was never satisfied with the use of any instruments unless he was entirely confident of their utmost accuracy, and to be certain of this, he was compelled to form them with his own hand. In the prosecution of his meteorological inquiries he convinced himself of the truth of the gyratory theory of Redfield and defended it with energy. In the more vigorous period of his life, he was a contributor to the mathematical periodicals of the day, solving the more difficult problems and proposing others. Among his correspondents in science, were Doctors Bowditch, Prince and Oliver, and President Jefferson.

Having at different periods engaged in the study of the law and acted some years as an attorney, he received the appointment of judge of the county court, and so far as a profound regard to justice is concerned, no appointment could have been more judicious. He knew nothing of dissimulation; nothing could influence him from the straightest line of uprightness. In his morals and in his dealings with men, he seemed to know nothing but the exactness of his mathematics.

He interested himself also in the politics of the day; was a member of the legislature of his native state several years during the period of the most rabid party divisions. As in science so in politics, he was a friend of Jefferson, and belonged to the old democratic party, and was twice elected to Congress. While at Washington he was not unmindful of his favorite themes, and it was proverbial among his colleagues, that in the recess of the sittings or when his seat was vacant, he could always be found at the Patent Office.

While his conscientiousness was a sufficient guaranty that no item of duty would for a moment, under any circumstances, be neglected, we are not among those who believe that the square and dividers are adapted to political purposes, however desirable a measure of the exact may be in the government of men and policy of the state; and the history of La Place is not the only comment upon this philosophy.

In the most laborious investigations, his patience was without limit. Nothing seemed capable of diverting him from his purpose, nor were the wants of his life deemed of any consequence to him when engaged in the solution of a mechanical or mathematical problem. Time was no object to him either in the prosecution of his own inquiries, or in imparting knowledge to his less learned neighbors and townsmen. But the object of this memoir is rather to commemorate the genius and acquirements of Folger than to comment upon his moral qualities. In reference to the latter, however, much might be said of his rigid virtues and abstemious habits; and although like Count Rumford he seemed at times soured and disappointed that men did not conduct themselves more in conformity with his own exact views, yet it was easy amid all this to perceive traces of good and benevolent impulses. He died on the 8th of the 9th month, 1849, at the age of 84.

Art. XXXII.—*On the Application of Photography to the Self-registration of Magnetical and Meteorological Instruments;* by Captain J. H. Lefroy, R.A., F.R.S., Director H. M. Magnetical and Meteorological Observatory at Toronto, Canada.

The successful application of the principle of self-registration by means of the action of light upon sensitive paper, or upon silvered plates, to observations in magnetism and meteorology, may be instanced as one of the most important indirect results of the great stimulus given to such inquiries by the encouragement and support extended to them for the last ten years by the governments of Great Britain, of Russia, and of various other countries, by the augmented attention of scientific bodies, and in short, by the more general recognition of their claim to an honorable place among the pursuits of science. Nor is it easy to foresee the full extent to which this principle may be destined in the end to supersede the tedious processes of personal observation, or the imperfect ones of delineation and description. In terrestrial magnetism, more particularly, it has been brought to perfection at a peculiarly appropriate time. From eight to ten years of laborious observations, have accumulated, probably, almost every thing that is essential for determining the numerical elements of its different periodical laws, and for a comparison of their operation in distant parts of the globe; but in spite of these observations, hourly, or two-hourly, by day and night, in spite of special observations upon all magnetical disturbances detected, and of term days designed to detect them but on which they seem to have made it a point not to occur; in spite of the extraordinary patience of Colonel Boileau in observing at Simla, not every hour, but every fifteen minutes, and of the perseverance with which Dr. Bache, at Philadelphia, multiplied his observations at the critical hours of each of the elements, in spite, in short, of all the efforts which have been made to obtain a full knowledge of the fluctuations of these most inconstant objects, it cannot be doubted that by far the greater, and perhaps the more instructive portion of all their changes, eluded the vigilance of the observers. In this state of things, therefore, a method which secures a minute and continuous graphical record of every change, and which can be put in practice with comparatively little difficulty or expense, is an acquisition to the science, second perhaps only to the invention by Gauss and Lloyd of the instrumental means upon which its previous rapid progress has been so largely based. The following description of the Photographical Instrument of Mr. Brooke, is based principally upon that gentleman's communication to the Royal Society in 1847,* and the advice and instructions with which the writer has been favored by him from time to time, in the establishment of one at Toronto. The various changes in detail which have been suggested by experience since the date of the paper referred to, and the possibility that the present communication may promote the establishment of other registers on this continent, will afford, it is hoped, a sufficient apology for its want of originality.

"In order to render any method of photographic registration practically useful, it is essential that the three following indications should be fulfilled.

"First, to obtain an easily managed artificial light of sufficient intensity to affect photographic paper, especially at those periods when it is of most consequence to obtain a continuous register, namely, when the position of the magnet is undergoing great and rapid variations.

"Secondly, to prepare by a ready process a photographic paper sufficiently sensitive to receive the feeble impressions of artificial light, and at the same time sufficiently durable to retain those impressions during a period of at least twelve hours, as a more frequent attention to the apparatus would probably interfere with the ordinary arrangements of an observatory.

"Thirdly, to magnify the movements of the magnet by some optical arrangement, so that the variations may be indicated with sufficient minuteness and accuracy."

The union of the three conditions is represented by a suspended magnet carrying a metallic reflector, by which a ray of light from a fixed lamp is thrown on the surface of a sheet of prepared paper, rolled round a glass cylinder, and made to revolve by a time piece.

The first of them, namely, that which relates to the light, was in the experiments of the first two or three years, attained by the employment of a camphine lamp. Mr. Brooke has recently succeeded in producing traces by the light of an oil lamp, which, although somewhat more expensive, is free from the inconveniences apt to attend the use of camphine. The camphine lamps, however, being still in use at Toronto, I proceed to describe them. The form of the lamp is square, two and a half inches on the side, one and a half deep; each contains about a quarter of a pint of the fluid, and is calculated, with *perfectly good camphine*, to burn twelve hours without requiring attention—in general it will be necessary to attend to it every six hours, by cutting off the charred end of the wick and refilling. A circular opening about 1·2 inch in diameter is made at the top near the centre of the side which is presented in front, this is stopped with a bone or ivory disk, and through the latter passes, by a narrow cut, made for the purpose, the burner or support for the wick, which is flat, half an inch wide and one-eighth of an inch in thickness. Common ball cotton may be used for the wick, by drawing as many lengths through the burner as fill it closely, but not tightly. A movable ring or collar with a set screw, allows the burner to be fixed at any required height, while, the stopper being movable, it can also be turned to form any required angle with the face of the lamp. Let us then suppose the lamp to be placed behind a screen containing a narrow vertical slit through which the light is to pass, and to slide in a groove so as to be always presented in precisely the same position; let us suppose also the screen in question to be fixed to the stand which supports the lamp. To begin, then, with the regulation of the light, the burner is first to be fixed at such a height that the top of the wick shall be exactly level with the bottom of the slit; it is then to be turned in azimuth so as to be presented edgewise at an angle of about 80° with the screen, or at such an angle as to give a cone of rays very slightly wider than the mirror. The support of the chimney of the lamp is then to be applied, and its height regulated so that the diaphragm by which the combustion is promoted, shall be about 0·10 inch below the top of the wick. Lastly, the chimney is added to the support, and the adjustments of the lamp are completed by applying the short cylindrical shade which fits under the legs of the chimney, and prevents all lateral diffusion of the light. The employment of camphine, although desirable on grounds of economy, as well as for the brilliancy and whiteness of its light, is attended with serious inconveniences. The fluid deteriorates very rapidly at summer temperatures 'by the absorption of oxygen, which converts a portion of the camphine into resin, which is held in solution in the remainder, and is deposited on the wick,' in fact it becomes perfectly useless; unless, therefore,

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* "Description of an apparatus for the Automatic Registration of Magnetometers and other Meteorological Instruments by Photography." By Charles Brooke, M.B., F.R.S., &c. Philos. Trans., 1847.

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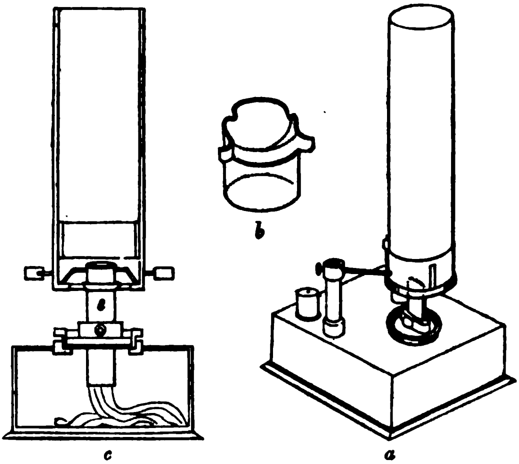

a. Lamps and chimney.—*b.* Ring placed under the chimney to cut off strong light.—*c.* Section of lamps, shewing the burner (*e*) and the diaphragm in the chimney.

the position of the observer enables him to procure constantly, fresh supplies of newly distilled fluid, he must expect trouble from this source. It has more than once happened that the resin about the wick and surface of the lamp has conducted the flame to the whole body of the camphine, which then burns with violence, but this ought not to occur if the lamp is *kept clean;* a more common inconvenience is its smoking, which occurs when the wick is too long, or the burner too high or too low relatively to the fixed diaphragm; great nicety is required in these points; but with bad camphine the utmost care can scarcely give security from the annoyance. Upon these grounds, Mr. Brooke, as already remarked, has recently turned his attention to devising a substitute, and by heightening the sensibility of the paper, has succeeded in producing good results with oil lamps. Gas, it is believed, has not been tried; where at command, it will probably prove by far the most convenient and effectual source of light.

The paper at present used for the register is prepared expressly for the purpose, the pulp being carefully freed from acid, alkaline, or saline substances. Where this cannot be procured, it should be the best highly glazed paper, not recently made, of the ordinary letter size before doubling, free from lime and other impurities, and of fine fibre. A paper called Whatman's yellow wove folio post procurable from importers in Canada, and bearing the date 1842, has been found to answer remarkably well. It is prepared as follows.

(1.) Dissolve five grains of fine isinglass in one fluid ounce of *distilled* water; the water should be poured boiling on the isinglass, and then set before the fire, and stirred occasionally until the latter is dissolved; perhaps this will require ten or fifteen minutes. As a portion is lost by evaporation, and afterwards in filtering, it is convenient to increase the quantity of both by one half, that is, to take an ounce and a half of water, and seven or eight grains of isinglass: while this is dissolving, weigh out twelve grains of the bromid and eight of the iodid of potassium, put both salts into a deep glass, such as a large wine glass. Extreme nicety in the quantities is not required, the effects having been produced with proportions varying from ten to sixteen grains of the bromid, and from two to eight grains of the iodid. The isinglass being sufficiently dissolved, filter one fluid ounce in quantity on the salts, through white blotting paper or filtering paper. The salts may be stirred with a glass stick, and the solution then set aside until cold.

The paper for a register of one element is cut lengthwise into slips of half the width of the sheet, each being about fifteen inches long, by four and three-quarters wide: if two elements are registered together, the undivided sheet is used. Having marked one side, for distinction secure the paper, with the unmarked side upwards, by a pin at each corner, to a clear pine board, rather larger than itself, and with a soft wide camel's hair brush kept exclusively for this purpose, apply the above solution uniformly and somewhat sparingly to its surface, taking care not to leave on it enough to run when the board is held to the fire, in which case yellow stains will be produced in consequence of a determination of the sulphuret of silver to parts which were too much wetted. Hold the paper on the board promptly to the fire so as to dry the solution uniformly and rapidly, and leave the salts very much on the surface; care must be taken not to scorch the paper. In brushing the paper, in this, as in all subsequent processes, it is well to take pains not to allow any of it to run over the edge, to the reverse side, where it leaves unsightly stains. Paper thus prepared, is not affected by light, and will keep a considerable length of time, but as it performs best when fresh, the inventor recommends the preparation of only a week's supply at once. An ounce of solution is sufficient for twelve or fifteen slips; on one occasion a paper of three months old at Toronto, yielded a good curve, but in general they present neutral patches to a greater or less extent, if kept too long.

The next step is to render the paper sensitive. For this purpose, prepare another slip of wood; secure a slip of the prepared paper to this, in the same way as before; exclude daylight, and make use of a lantern glazed with red or yellow glass, then pour into a capsule about a teaspoonfull of the following solution.

(2.) Dissolve fifty grains of nitrate of silver in one ounce of distilled water; apply it to the paper lightly and carefully, brushing first longitudinally, then across; it is scarcely necessary to say that each solution must have its own brush, its own cup, and even its own cloth for drying the cup and brush.* The paper being uniformly wetted, roll it immediately round the glass cylinder, which must be previously wiped dry, and secure it, where the ends overlap, by a little gum dissolved in acetic acid. If but one lamp is used, it is necessary to make a couple of pencil marks across the junction of the folds, to furnish a base line. The light being then allowed to fall on the paper at any chosen moment of time, the trace commences. The above directions apply to the ordinary process when camphine is used; to give the paper the additional sensibility required with an oil lamp, Mr. Brooke directs to rinse the paper in water after applying the nitrate of silver, holding it by the two ends and shaking it a little, under the surface of the water in the dish. It is then to be laid on a cloth, and the water pressed out of it, by passing a glass rod or piece of tube two or three times over it, with gentle pressure. (To avoid the contact of organic matter with the prepared surface.) About half a teaspoonful of the nitrate of silver solution is then poured on the paper, and the glass rod again passed lightly over it, which diffuses the solution over it; after which it is applied to the cylinder as before; by this process the sensibility of the paper is said to be much increased, and it keeps a cleaner surface. To present at one view the different chemical processes, we will suppose the cylinder to be now left to complete one revolution (of twelve hours) or two, as the case may be, the paper has then to be removed, the impression to be developed, and then fixed. For this purpose a common large dish is required, which should be placed before a fire until moderately warm. Excluding daylight as before, remove the cylinder carefully from its supports, take off the paper with as little fingering as possible, and lay it on the dish; no indication of the trace will be perceived, unless the disk be more than duly heated, in this case the lines sometimes appear faintly without farther treatment, but the paper darkens too much afterwards. It has to be now brushed with

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* A small covered box having a place for each cup, each bottle, and each brush, will be found convenient. The cups should be further distinguishable by some difference of shape or color, and the brushes marked.

(3.) Twenty grains of crystallized gallic acid, dissolved in one ounce of distilled water* when it appears in a minute or two. When the impression is sufficiently distinct, which will generally be in the space of five minutes, the gallic acid must be washed off by repeated sluicings with soft water, assisted by a soft brush. In a cold place, or with a cold dish, a longer time is required; in short the whole process seems to succeed best, like most photographic processes, at a high temperature, although the trace has been developed at a temperature low enough to convert the solution into a film of ice. When the uncombined nitrate of silver and gallic acid are thoroughly washed off, the light may be admitted without danger; it then remains to fix the impression by transferring the paper to a clean dish or board, and brushing it with about one table spoonful of the usual solution, namely,

(4.) Twelve grains of hyposulphite of soda to one ounce of distilled water. It will be observed that rather a larger quantity of this solution is laid on the paper than of the previous ones. If an insufficient quantity be applied, or it be not uniformly distributed, the paper is apt to acquire a dirty brown stain, in patches, passing into black, which latter it ultimately becomes when no hyposulphite is applied; in this case, the margin of the previously dark lines becomes the lightest portion; after allowing the hyposulphite a few minutes to act, it must be thoroughly washed off, by repeated sluicings of water, assisted as before, with a soft brush, otherwise it enters into a new combination which spoils the specimen: the paper may then be placed between the folds of clean white blotting paper until dry, when the process is completed.

We may now return to the mechanical details. The magnet employed is about two feet long, one inch and a quarter wide, and a quarter of an inch in thickness: it is suspended with the broad side vertical, in a brass stirrup carrying a divided circle (*a*) by which the position of detorsion of the thread is made to coincide with the meridian, and two keepers (*b*, *b*) capable of sliding on the stem (*d*) for the purpose of holding a metallic reflector (*m*). This important part of the apparatus is a small speculum weighing about one pound, four inches in diameter, and of about sixteen inches focus; it can be set to any required height on the stem (*d*) and be made to form any required angle with the axis of the magnet. The whole suspended weight amounts to about four and a quarter pounds, requiring a strong silk suspension; hence that the effect of torsion may be moderate it is desirable to have it of considerable length.* At Toronto, three wooden pillars, firmly fixed in the ground, and passing through the floor (without contact) carry a triangular frame on which is erected a light tripod stand, which passes through an upper floor, and supports the reel to which the suspension silk is attached, allowing a length of about ten feet. Stone pillars would be preferable, and have indeed been prepared for another instrument, a bifilar, on the same principle, which will, it is hoped, be brought into operation in the course of the present spring; it is probable that many interesting enquiries will arise out of oscillations so minute, that

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* One ounce of water will not hold twenty grains of gallic acid in solution at ordinary temperatures; it is necessary to dip the bottle in boiling water, or heat a small portion of surcharged solution, in a test tube.

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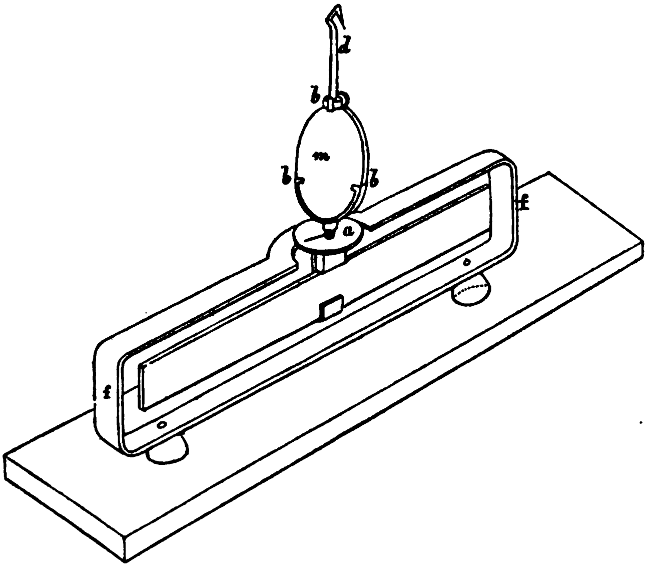

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* A long silk suspension is, however, liable to the inconvenience of varying sensibly in different hygrometric states of the atmosphere, thereby disturbing the adjustment of the light sufficiently in some cases to make it ineffective. A fine metallic suspension, as was originally used by M. Gauss, for his declinometer, if very long, would probably be preferable to silk.

nothing but extreme care, in cutting off every source of external or mechanical agitation, will give security to them. Mr. Brooke has given a curious lithograph of a trace produced under extreme "local disturbance," namely, a *quadrille party* in the house adjoining, which is sufficient to shew that if the tremor communicated from such sources does not altogether annul the magnetical movements, it materially modifies them. It will also be found necessary to adopt some means of rapidly reducing the natural movements of the magnet, of which by far the best, is the application of a heavy copper ring or damper, as shown in the preceding diagram (*f*); if the bar be very strongly magnetized, a fine wire dipping into mercury may be attached to it, but where the magnetism of the bar is feeble, or the horizontal component of the force has a low value, this method seems objectionable.

We have already described the lamp. It will be seen that when placed before the mirror an image of the vertical slit through which the light passes will be formed in the conjugate focus: this image being condensed to a point, by the intervention of a lens of any kind, any angular movement of the magnet and mirror will cause a movement of that point through a space equal to twice the tangent of the angle, to radius the distance of the image from the mirror; the trace can therefore be made upon any required scale, by varying that distance. At 7 ft. 2 in. it will be 20′ to 1 inch, at 9 ft. 6½ in. it will be 15′, and at 11 ft. 11¼ in. it will be 12′ to 1 inch; the distance to be selected must be determined by the probable range of the element in ordinary magnetic disturbances, for since very great ranges are of rare occurrence and seldom more than momentary, it does not seem expedient to réduce the scale sufficient to include them, at the sacrifice of distinctness in the more usual movements.* The scale at present in use at To-

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* The width of the half sheet of paper is sufficient for a range of 40′ of declination and ·008 of horizontal force, upon the largest scales likely, under any circumstances, to be adopted, namely 10′ of declination and ·002 of horizontal force, to one inch. It appears from observations at Toronto, from 1840 to 1849 inclusive, embracing altogether about 3050 days, and including 164 occasions of extra observations, and 118 term days, that great ranges may be expected at that station in the following proportion.

Range of Declination.		Range of Horizontal Force.	
Less than 40′	2978 days.	Less than ·008	2974 days.
From 0° 40′ to 0° 50′	28	From ·008 to ·010	17
0° 50′ to 1° 0′	12	·010 to ·015	19
1° 0′ to 1° 10′	4	·015 to ·020	7
1° 10′ to 1° 20′	7	·020 to ·025	9
1° 20′ to 1° 30′	2	·025 to ·030	3
1° 30′ to 1° 40′	2	·030 to ·035	7
1° 40′ to 1° 50′	1	·035 to ·040	3
1° 50′ to 2° 0′	4	·040 to ·045	2
2° to 3°	6	·045 to ·050	1
3° to 4°	2	·050 to ·055	2
More than 4°	3	More than ·055	11

On 211 of the term days and disturbances, the range of declination fell within the above limits, (40′) and on 207 of them, the range of horizontal force fell within the ronto is 20′ to an inch, the light being thrown in such a way as to divide the space unequally, and allow the greatest range to the east, the direction in which the principal movements occur.

The lamp is supported by a tripod stand about three feet high, with an elevating lever for raising the top, which consists of three distinct parts: the lowest of these (*a*) turns in azimuth round a pivot, the second (*b*) slides by a slow motion screw, in a groove, on the face of the first, the third (*c*) slides in like manner on the second, but transversely: by these arrangements, first, the luminous slit can be set at any required height, secondly, it can be turned in azimuth until the brightest part of the ray falls on the centre of the mirror, thirdly, its distance from the mirror can be adjusted until a sharp focal image is formed on the cylinder, lastly, it can be moved laterally, so as to carry the image to any part of the paper required; this effect can be produced also by turning the mirror itself a little, but not with the same facility. The upper plate is provided with a groove, into which the lamp is made to fit, thus securing its being replaced after each change in precisely the same position; it also carries the screen. The slit through which the light passes is about 0·4 (four-tenths) inch high and from one to two-hundredths of an inch wide; the width can be varied at pleasure by a sliding piece and slow-motion screw.*

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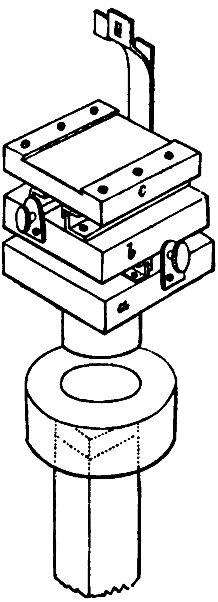

Lamp stand.

The stand for the support of the cylinder, requires, like that of the lamp, some means of adjustment in height. If a barometer is connected with the apparatus, a ready means of attaching it so that the index may pass through the table top near the cylinder, must also be considered; both objects may be obtained by adding a solid table top about sixteen inches square to a tripod stand similar to that of the lamp, the feet of which should rest on a solid support.

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limit allowed for that element. It is to be expected that many more disturbances in proportion will be recorded by the photographic process than were observed, but not of the more extreme degrees, or such as to alter materially the above scale of relative frequency.

* The position of the stand for the lamp must be such that the cone of rays reflected from the mirror shall not quite clear the chimney, which cuts off a portion of one edge of it, while a portion of the other edge is cut off by a screen slipped a little before the mirror: seen therefore from the centre of the cylinder, the chimney should hide a small segment of the mirror on one side, and the screen a similar segment on the other.

The cylinder consists of an ordinary French glass shade, blackened on the inside, about fourteen and a half inches in circumference and ten inches high. One end is closed by a metal cap provided with a concentric axis, three inches long, a bent arm or crank is attached to the axis by a set screw, and engages with a slit in the hour hand of the time piece, by which the whole is made to revolve. The weight of the cylinder is borne upon five friction rollers set in a light frame; two of them, which carry the axis, are set vertically facing the time piece, two more, of smaller size at the opposite end of the frame, are sufficiently separated for the body of the cylinder to rest upon them, near its hemispherical end; the other is set horizontally, and works against a small brass plate at the base of the axis; the whole should be carefully turned and truly pivoted. In the arrangement of the inventor, after placing the paper on the cylinder as here described, a second cylinder very slightly larger is slipped over it, and retained in a concentric position, by pressure upon a few coils of tape wound round the capped end of the inner cylinder and kept wet; the object is to protect the paper and keep it damp, for which purpose, also, a piece of wet lint is placed between the cylinders at the point. An accident to the external cylinder led to the adoption of a different plan at Toronto, which has been found so convenient that the former one has not been reverted to. The external cylinder is replaced by a case of copper, of about the same size and shape, but divided along the axis into two halves, one of which is fixed to the frame carrying the friction wheels, (of which, the two carrying the axis, run altogether outside of it, the others enter it through narrow cuts, sufficiently to carry the cylinder clear); the other half forms a covering removable at pleasure. The light is admitted through two narrow slits, which may be glazed if desired. The advantages of the arrangement are these. The time piece has but half the weight to turn; the paper is immediately accessible; the loss of light in passing through the external cylinder is avoided, since it is found in practice unnecessary to glaze the opening, the impressions are therefore darker; the paper may be applied, and removed with great expedition, and without exposure to stains from contact with the

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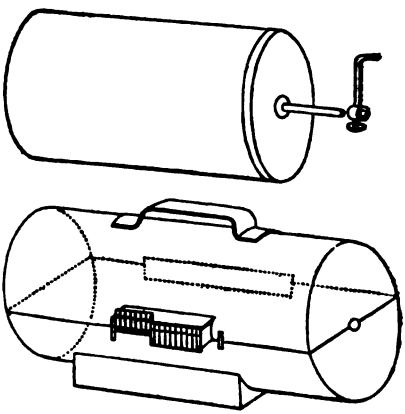

Cylinder and Copper case.

wet edges of the external glass cylinder; lastly, we are enabled, by the employment of the sliding screens described below, to make use of nearly the whole width of the paper for barometric changes, instead of being restricted to about one-half of it. It should be added that by making a shallow well in the fixed half of the cylinder, a large surface of wet lint may be exposed immediately under the paper, which is found to keep it damp enough under all circumstances, even when the slits are open.

The barometer employed, is a syphon, "constructed with a column of mercury of a little more than one inch in diameter. As the weight of an entire column of this size would be inconvenient, and as it would be difficult to obtain a tube more than three feet long of so large a bore, both ends of which were of the same internal area, two adjacent short pieces of a very nearly cylindrical tube, have been united to the extremities of a tube of small bore, and form the ends of the instrument which contain the surfaces of the mercury," thus shewing the variations of pressure by an equal change of half the amount in either tube. These changes are communicated to a long and slender index or lever by means of a float, attached to a short arm at right angles to it, both being centred on a light wheel of metal, carefully pivoted, and both being counterpoised. The float actually employed is the bulb of a mercury thermometer, the stem of which passes through a cap adapted to the open end of the syphon, and is guided by three small friction rollers.* A screen of card or very thin metal, provided with a narrow slit exactly thirty inches from the centre of motion, is attached to the upper end of the long index, covering an opening in the copper case of the cylinder; a lamp being then fixed behind the screen, the pencil of light which falls on the paper through the slit left for the purpose, will, it is evident, follow every change in the position of the index, or of the surface of mercury in the syphon. A lens similar to that which is used to bring the elongated image of the slit reflected from the mirror of the magnet to a point, is also used here to bring the image of a horizontal slit in a corresponding screen before this lamp, to a focus on the paper. It forms a bright line across its whole width, which is however intercepted by the barometer screen on one side, and by an independent screen on the other, allowing to reach the paper, only the variable pencil passing through the former and an invariable one, for the purpose of tracing a base line through a fixed opening in the latter.

The tube of the barometer has a vertical movement, to allow an adjustment of the level of the mercury at the foot of the syphon, to the same horizontal plane, so that whatever be the pressure at the time of commencing a trace, the long index is set vertically. By varying the ratio of the lengths of the two levers we may enlarge the scale of the trace to any extent; for this purpose there are distances marked on the short arm, corresponding to a scale of three, four, and five times the actual change, and the axis to which the arms are fixed can be moved nearer to, or further from the float as required. The nature of the scale must in general depend upon the probable extent of the barometric changes in twelve or twenty-four hours; it may be greater in the summer than in the winter months, but there will always be some changes exceeding the range of the instrument, or rather, the width of paper available for their registration. As, for instance, when the barometer falls or rises an inch in twenty-four hours: in such cases the index may be brought afresh to the vertical position during the progress of the register. Not to interfere with the magnetical curve, the barometer should be so placed as to form its trace rather on one side of the paper, thus reducing the space available in that direction to about one-third of its width; but by a particular contrivance connected with the copper case already described, we are enabled, without liability to exposure, to command nearly the entire width in the other direction. This contrivance consists of a set of twelve narrow parallel sliders, occupying in width about 1½ inch, moving vertically in a frame attached to the upper half of the cylinder, and capable of being raised or lowered at pleasure. At the commencement of a trace, we may suppose half of them to be raised; the remainder being down, the screen at the top of the index completely excludes all other light from the paper than the pencil passing through its own slit; but if the barometer falls beyond a certain amount, the edge of the screen will at length pass beyond the last slider, leaving a portion of the paper fully exposed; in such a case, one or more sliders are put down: if on the other hand the barometer rises to a certain amount, the light will at length fall on the space covered by the sliders, and it becomes necessary to raise some of them; in this way, the black bands caused by the accidental exposure of the paper, under extreme movements of the barometer, may be avoided.

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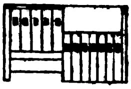
* These have been generally dispensed with, at Toronto, and the end of the syphon left open: unless very truly turned, and perfectly centred, they are apt to impede rather than assist the motion of the stem of the float.



The cylinder, with the two fixed lenses, the time piece, and the upper end of the barometer index, are all included under a second or external case, provided with apertures for the admission of the rays of light, and with a lid at the top to allow access to the sliding screens of the barometer. The apertures are of the same width as the fixed lenses, and each provided with double sliders by which they can be contracted at pleasure; that appropriated to the magnetical trace is protected by a long rectangular tube, the effect of which is so complete, that "not the slightest difference can be perceived on the paper whether bright daylight is freely admitted into the room or wholly excluded."

Every part of the apparatus from which light can be reflected, directly or indirectly, to the paper, is carefully blackened.

I have described the apparatus at some length, because with the exception of the speculum, the cylinder itself, the time piece, and the tube of the barometer, all of which must, at present, probably, be procured from Europe, there is nothing which an ingenious mechanic might not execute at a small cost; the fixed lenses should perhaps be added; but a simple substitute for them may be found in a well blown cylinder of thin glass filled with alcohol, as was indeed employed by Mr. Brooke in his first instrument. The more expensive lenses at present in use are manufactured by Lerebours of Paris, and may be described as lenticular prisms having a double convex section, but forming a flat bar, which is from seven to eight inches long and one inch and a quarter wide for the magnetical curve, and about five inches long for that of the barometer and base line. Each lens is mounted on a light frame which slides in a groove so as to admit of adjustment of focus. The focus is rather improved by covering a portion of the margin of the lens.

It is advisable on the first adjustment to bring the centre of the mirror, of the cylinder, and of the slit before the lamp, into the same horizontal plane, and to establish some marks for its recovery in successive adjustments, as much of the perfection of the focus depends upon this circumstance. If it is found that the mirror when thus adjusted, throws the image of the slit too high, or too low, its own inclination must be altered by introducing a small wedge of cork behind it. Small derangements produced by spontaneous alterations in the length of the suspension silk may be corrected by raising or lowering the lamp, and must be carefully attended to.

A perfectly good trace, according to the experience of the writer, presents a sharp edged dark line, of a purple tint, upon a yellowish ground. The lineal value of one hour in time, is one inch and two-tenths (nearly), the value of a full revolution appears to differ in different traces (from unequal expansion and contraction of the paper) to the amount in the most extreme cases of about one-tenth of an inch, upon a total length of nearly fourteen and four-tenths; but it will be evident that the precise equality of the different hours will depend in some measure upon the regularity of the cylinder's form, and the precision with which it is centered. There appears to be considerable diversity in the character of the traces produced by different observers, owing both to differences of treatment, and to impurities in the chemical materials. The yellow ground alluded to, is probably the effect of the large proportion of iodid of potassium employed, the object of which is, to insure the permanence of the effect for the long period of twenty-four hours, during which a part of it, at least, is to be maintained upon the surface of the paper; when a less quantity of iodid is used, the paper appears to have a neutral tint: in this case, the beginning of the trace can sometimes be with difficulty developed. The greatest care must be taken not only to prevent the least intermixture of substances, and to confine each vessel, and each cloth, as well as each brush strictly to one use, but also to wash all the brushes very carefully in pure water after use, not only for their preservation, but because the presence of deposit from old solutions, even of the same kind, has an injurious effect.

A room of 12 × 15 feet is all that is absolutely needed for a single instrument. It will be found very desirable to have a small cistern of soft water in it, provided with a stop cock, and with a sink and waste water pipe attached; the sink should have a lid to allow the paper to be kept in darkness, when convenient, without darkening the room: if to this we add two or three broad shelves, or small tables and conveniences for washing the hands, its equipment will be complete.

The future comparison of traces will be greatly facilitated if they all include the same period of absolute time. Each register at Toronto begins at 20′ after 6^h of Göttingen mean time, and terminates at 6^h 0^m of the following day, being nearly at Toronto noon.

"A continuous registration of the variations of the thermometer has been obtained by intercepting the focal line of light formed on the paper, by the stem of a thermometer having a wide flat bore, a sufficient quantity of light passes through the empty portion of the bore to darken the paper, but it is entirely excluded from the portion occupied by the mercury. The register, therefore, consists of a light and dark space, separated by a well defined boundary line the distance of which from the base line will furnish the required indication. This particular application of the apparatus, prefers no claim to novelty, as a very similar means of registering the variations of the thermometer has been already published, (Engineer's Magazine, Nov., 1845,) and is here introduced merely as forming a necessary part of a complete automatic meteorological registration."

Allusion has been made at the commencement of this article, to the action of light upon silvered plates, as one of the modes of effecting the self-registration of magnetical instruments. The apparatus referred to is the invention of Mr. Ronalds, and although capable of employing either paper or metallic surfaces, is properly designed for the latter, and is essentially a daguerreotype. An instrument on this principle was sent from England for the Magnetic Observatory in August last, but by accident to the vessel, has not yet been received there, and cannot now be brought into operation before June, 1850. It is intended to register the horizontal force, and differs essentially in many respects from the apparatus of Mr. Brooke. A bifilar magnet adjusted in the ordinary way, carries a light movable screen, passing before the object glass of a camera, which faces a north window, at the distance of four or five feet. It acts therefore by refraction, instead of reflection. The ray which passes through the screen is received upon a silvered plate prepared by the common daguerreotype process, somewhat modified to adapt it to a slow and long continued action. The plate is made to travel slowly before the light in a vertical plane, by the action of a time piece: the distance of its surface from the centre of the magnet being about thirty-four inches, a sufficiently large scale is allowed to render sensible very small movements of the horizontal force, provided a due degree of sensibility is given to the balance of forces by which the magnet itself is held in equilibrium. In other words, provided the ratio $\frac{F}{G}$, in the common notation, is made to approach nearly to unity. Mr. Ronalds has succeeded, in the climate of London, in producing effects by natural light so late as 8 P. M. in the summer. For the nocturnal portion of the curve a powerful argand lamp is employed.

The relative merits, in practice, of the two valuable and ingenious inventions now described, can scarcely be stated at present. That of Mr. Brooke has probably the advantage in economy and facility; that of Mr. Ronalds will, it is expected, prove capable of a higher degree of precision, and it offers a convenience of which the inventor has already availed himself. Any trace of unusual interest can at once be engraved on the plate, thus giving the utmost possible accuracy and facility to graphical comparisons. It is not intended however under ordinary circumstances to retain the impressions, but after recording every particular of interest, and tabulating the hourly or other ordinates, or taking a copy of the traces, to clean them off and make use of the plate again as long as the silvering lasts.

In conclusion the writer begs leave to add that should the foregoing account lead to the establishment of any instruments of the kind, he will have pleasure in giving any further information in his power in answer to personal enquiry. Without presenting facsimiles, it is difficult to convey an idea of the interest attaching to many of the movements which have been registered, but the important information which such records are calculated to afford as to the periodicity of certain movements, the nature and degree of local anomalies in disturbances of the magnetical elements, the effect of Aurora, and many other enquiries, will occur immediately to any one interested in terrestrial magnetism, and it is hoped secure the adoption of a register upon one or the other principle, by more than one of the numerous scientific establishments in the United States.

Toronto, January 21, 1850.

Postscript.—In the foregoing account of the instrument of Mr. Brooke, it has been assumed that the arm of the cylinder is connected directly with the hour hand of the time piece, making it therefore revolve once in twelve hours. The effect of this arrangement is, that when the paper is left on for twenty-four hours, we have two traces, which sometimes intersect in such a manner, as to make it difficult to distingnish to which revolution portions of them are due. The writer has recently succeeded, by a very simple arrangement, in making the cylinder revolve but once in twenty hours, and thus remedying this inconvenience. Two small grooved wheels mounted on a light frame, one having a diameter exactly double that of the other, are connected by a piece of fine silk twist. The smaller one being then connected with the hour hand, by a crank, and the larger one with the cylinder, it is evident that the object is effected.

This reduces the time scale to six-tenths of an inch for one hour, which is fully equal to the scale that has been generally adopted in the engraved diagrams of term day and other movements, and is considered large enough for almost every purpose to which diagrams can be applied, while it gives great facility to comparisons, and a much more distinct representation of the diurnal curves.

Art. XXXIII.—*Influence of the known Laws of Motion on the Expansion of Elastic Fluids;* by Eli W. Blake.

That under the controlling influence of the known laws of motion, elastic fluids must expand according to some definite and invariable law, is an obvious truth and one which has often been recognized by mathematicians. But the determination of that law is a problem which hitherto, it is believed, has not been solved. There are many interesting points in mechanics and physics, in relation to which the present state of knowledge is imperfect, which depend for their correct and complete development, in part at least, on a solution of this problem. It is therefore a point of some interest to science. It is our purpose in this article to solve this problem; and we shall do so by employing a method similar in part to that employed in solving the problem of the propagation of pulses in elastic media, ii ser., vol. v, p. 372, of this Journal.

Before entering upon the investigation we will here state one curious and remarkable fact which the investigation discloses. We advert to it here because a fact so much at variance with preconceived notions may be interesting to those readers who will not care to follow out the mathematical details of this article.

When a fluid passes by free expansion from one state of density to another, we should naturally suppose that it must pass through all the intermediate states of density that can be assigned between the two. Such appears to have been the notion of every writer who has made reference to this point; and at first view it would seem absurd to suppose that the fact could be otherwise. But such is not the way in which elastic fluids expand. On the contrary the parts of the fluid successively and *instantaneously* change their density, to the extent of one half (when free to expand to that extent) *without passing into the intermediate states.* As vapor is thrown off from the surface of water in a tenuious state *ab initio*, and without having first passed into those states of density which are intermediate between the density of the water and that of the vapor, so a column of rarefied fluid is thrown off from the front of a denser column; each infinitesimal element of the highest order of the denser column, being successively and instantaneously transformed to the more rare state. And as the change of density is instantaneous, so likewise the entire velocity due to that change is imparted instantaneously to each element successively.

But to proceed with the investigation; suppose a straight tube of uniform calibre extending indefinitely in both directions from a given point. Suppose the tube on one side of this point to be filled with a column of fluid of the density D, indefinitely expansible, and always maintaining the same ratio between its density and elastic force when it expands; and suppose the other portion of the tube a perfect vacuum. It is required to determine the law according to which the fluid expands into the vacuum; so that we may be able to assign the precise state of the fluid, in respect to density and velocity, at each and every point of the tube after the lapse of any given time from the commencement of expansion.

Since the elastic force is always as the density, D may represent both the density and the elastic force. The force D acts during the first instant in every part of the column, and in *every direction;* and therefore during that instant every part of the column is kept in equilibrio except the first element. Consequently in the first instant expansion takes place in the first element only; and as the whole force D acts during that instant, the parts of this element must receive such velocities that the sum of their momenta shall be equal to that due to the action of the constant force D during that time. It is obvious that the termination of the first instant coincides with the commencement of motion in the second element; also that motion will not commence in the second element until the density in front of it has been to some extent reduced. Let the ratio in which it is reduced before motion begins in the second element be represented by $\frac{1}{x}$. Then the density of the posterior part of the expanded element at the end of the first instant is $\frac{D}{x}$. Now for reasons which will soon be apparent, all the other parts of the expanded element, whatever may be their present state of density, may be considered as having passed first into the density $\frac{D}{x}$. But at the same time that the grade $\frac{D}{x}$ began to form in front of the column, that grade itself must have begun to expand *again* in the same ratio, forming another grade $\frac{D}{x^2}$. And at the same time that the grade $\frac{D}{x^2}$ began to form, that likewise must have begun to expand in the same ratio forming a grade $\frac{D}{x^3}$, and so on ad infinitum. The grades therefore will correspond to the terms of an infinite series in decreasing geometrical progression. All of them originate *simultaneously* in the first element; and yet every grade respectively may be considered as having passed into and out of all the grades which precede it; inasmuch as each in its origin is a *constituent part* of that which precedes it. The fluid which passes into any one of these grades in the first instant does not all of it pass into the next in the same time; for equal quantities by *measure* expand in equal ratios in equal times; and since a given quantity by measure in any one grade becomes a larger quantity by measure when expanded into the next grade, a portion will have been left at the end of the first instant in each grade which has not expanded into the next. Hence at the end of the first instant the first element of the column will have been distributed into portions or grades, having their respective densities corresponding to the terms of the infinite series

$$\frac{D}{x}, \frac{D}{x^2}, \frac{D}{x^3}, \frac{D}{x^4}, \&c. \qquad (A)$$

If we extend this series backward one term we obtain the series

$$D, \frac{D}{x}, \frac{D}{x^2}, \frac{D}{x^3}, \frac{D}{x^4}, \&c. \qquad (B)$$

Since equal quantities by measure pass out of each of these states in a given time, if s be the space occupied by the original element, and if we multiply each of the terms of the series (B) by s, then the terms of the resulting series $Ds, \frac{Ds}{x}, \frac{Ds}{x^2}, \frac{Ds}{x^3}, \frac{Ds}{x^4}$, &c. (C) will severally express the quantities of fluid that expand from each grade respectively into the next. Now since fluids expanding in equal ratios acquire equal velocities, equal velocities are acquired in each of these expansions. If then we find that velocity and by it multiply the sum of the series (C), the product will be the sum of the momenta generated in, or imparted to, the parts of the first element in the time in which the point of expansion recedes through s.

If the quantity Ds be expanded from the density D to the density $\frac{D}{x}$, the space it will occupy will be increased in the inverse ratio of these densities; and therefore $\frac{D}{x}:D::s:sx$. Hence s and sx are respectively the spaces occupied by the element before and after the first expansion. Now the velocity which the mass Ds receives in this expansion, is obviously that which would carry it over the difference between these spaces in the time in which the expansion takes place; that is, the velocity imparted in the first expansion is $sx-s=s.\overline{x-1}$; and the same velocity is imparted in every other expansion. If then we multiply the sum of the series (C) by $s.\overline{x-1}$, the product will be equal to the sum of all the momenta generated in the parts of the element. This product is Ds^2x. Therefore Ds^2x is the entire amount of momentum which the force D is competent to generate in the time in which the point of expansion recedes through s.

We will now proceed to find another expression for the momentum which the force D is competent to generate in the same time, in order that by comparing it with that just found, we may ascertain the value of x.

Let H be the height of a column of fluid of the density D, whose weight is equal to the elastic force D; and let $H-h$ be the height of another column of the same density whose weight is equal to the elastic force $\frac{D}{x}$. Then $D:\frac{D}{x}::H:H-h$. Let mn be the space occupied by the first element at the density D, and ms that which it occupies when expanded to the density $\frac{D}{x}$. Since the spaces occupied by the element in these states are inversely as the densities, $mn:ms::\frac{D}{x}:D::H-h:H$, and therefore

$$ms-sn:ms::H-h:H;\ \text{whence we obtain}\ H=\frac{h\times ms}{sn}.$$

In the time in which the point of expansion recedes through mn, the element Ds receives a velocity which will carry it over sn in the same time. If then mn represent the velocity of the point of expansion, *sn* will represent the velocity imparted to the fluid by the first expansion. Consequently, the retrogressive velocity of the point of expansion must be such that in the time in which it passes over any space, the force $D-\frac{D}{x}$ may give to all the fluid in that space the velocity *sn*. Hence the point of expansion will run over *h* in the time in which the force $D-\frac{D}{x}$ will give to all the fluid in *h* the velocity *sn*. But the force $D-\frac{D}{x}$ is equal to the *weight* of all the fluid in *h*. Therefore the point of expansion runs over *h* in the time in which the mass *h* would in falling by its own gravity acquire the velocity *sn*. The time in which a falling body acquires the velocity *sn* is to that in which it would acquire the velocity of the point of expansion, or *mn* as *sn* to *mn*; and the spaces over which the point of expansion would run in these times are in the same ratio. Therefore putting S for the space which the point of expansion would run over while a falling body would acquire the velocity of the point of expansion, we have $sn:mn::h:S$, or, $sn:ms-sn::h:S$; whence we obtain $S=\frac{h\times ms}{sn}-h$. But we have before found $H=\frac{h\times ms}{sn}$. Therefore $S=H-h$; that is, the point of expansion will run over $H-h$ in the time in which a falling body will acquire the same velocity. Consequently the velocity of the point of expansion is that which a body will acquire by falling through $\frac{H-h}{2}$.

If the force D act on the mass H during the time that mass would fall through H, it would give that mass a velocity which would carry it over 2H in the same time, because the force D is equal to the weight of the mass. The mean velocity of a body falling through H is that which will be acquired by falling through $\frac{H}{4}$. If then the point of expansion moved with the velocity acquired by a body in falling through $\frac{H}{4}$, in the time of passing over H, the force D would be competent to give to all the fluid in H a velocity which would carry it over 2H in the same time; and consequently in the time of passing over *s* it would give to the mass D*s* a velocity which would in the same time carry it over 2*s*. But the point of expansion as before shown, moves with the velocity acquired by falling through

$\frac{H-h}{2}$. Now the velocity due to $\frac{H}{4}$ is to that due to $\frac{H-h}{2}$ as $\sqrt{\frac{H}{4}}$ to $\sqrt{\frac{H-h}{2}}$; and the times in which the point of expansion would move over s with these velocities, are inversely as these velocities, or as $\frac{1}{\sqrt{\frac{H}{4}}}$ to $\frac{1}{\sqrt{\frac{H-h}{2}}}$. But $D:\frac{D}{x}::H:H-h$, and therefore these times are as $\frac{1}{\sqrt{\frac{D}{4}}}$ to $\frac{1}{\sqrt{\frac{D}{2x}}}$, or as 2 to $\sqrt{2x}$. The velocity which the force D can impart in these times is as the times respectively. And since it has been shown that in the former of these times the velocity $2s$ will be imparted by the force D, we have $2 : \sqrt{2x} :: 2s : \frac{2s\sqrt{2x}}{2} = s\sqrt{2x}$. That is, the *velocity* which the force D is competent to impart to the mass Ds in the time in which the point of expansion recedes through s, is $s\sqrt{2x}$. Consequently the *momentum* which the force D can impart in the same time is $Ds^2\sqrt{2x}$. But we have before found this momentum to be Ds^2x. Therefore $Ds^2x = Ds^2\sqrt{2x}$; whence $x=\sqrt{2x}$ and $x=2$.

Having thus found the absolute value of x, if we substitute this value for x in the series (A) we shall have, for the densities of the several parts or grades into which the first element will have been distributed at the end of the first instant, the respective terms of the following series, viz., $\frac{D}{2}, \frac{D}{4}, \frac{D}{8}, \frac{D}{16}, \frac{D}{64}$, &c.

We found the velocity of the point of expansion to be that which a body will acquire by falling through $\frac{H-h}{2}$; the value of h being dependent on the value of x. But when $x=2$, $\frac{H-h}{2}=\frac{H}{4}$. Therefore the absolute velocity of the point of expansion is that which a body will acquire by falling through $\frac{H}{4}$, or one fourth of the subtangent of the fluid.

Since the extent of the element is doubled by the first expansion, the velocity of the first grade will be equal to the velocity of the point of expansion, or that due to one fourth of the subtangent; and an equal additional velocity is imparted in each succeeding expansion. If then v represent the velocity due to one fourth the subtangent of the fluid, the absolute velocities of the several grades respectively will be expressed by the respective terms of the series v, $2v$, $3v$, $4v$, $5v$, &c.

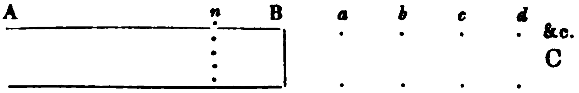
Since one element $=s$ by measure passes from each grade into the next, and becomes $=2s$ in the next, the length of each grade at the end of the first instant $=2s-s=s$. That is, the length of each grade is equal to that of the original element; and the *place* of the first grade is that which was occupied by the original element; the other grades succeeding it in continuous order.

Having now ascertained the state of things at the end of the first instant, let us inquire what takes place in the second instant.

It is obvious that during the second instant the front of the second element of the column, and also the front of each grade respectively is a point of expansion from which one element $=s$ by measure passes into the next grade. Thus in the second instant each grade receives an addition of $2s$ to its rear and loses $1s$ from its front. The same takes place in every succeeding instant. Since the increment of the length of the grades for each instant is s, the velocity of the increase is v. The length of the grades is therefore always equal to the space through which the point of expansion has receded in the column. Thus while the length of the grades increases with the uniform velocity v, their number, velocity and density remain unchanged. Consequently no other gradations of density can exist in front of a column expanding into a vacuum, but those which correspond to the terms of the infinite geometrical series $\frac{D}{2}, \frac{D}{4}, \frac{D}{8}, \frac{D}{16}$, &c.; and no other gradations of velocity but those which correspond to the terms of the infinite arithmetical series v, $2v$, $3v$, $4v$, &c.

The point of expansion in the column recedes with the velocity v; and since the length of the first grade is always equal to the space through which that point of expansion has moved, it follows that the point of expansion from the first into the second grade is stationary. And since the second grade increases in length with the velocity v, the third point of expansion moves forward with the velocity v; and since all the other grades increase in length with the same velocity v, the velocities of the several points of expansion will be expressed by the following series $-v$, 0, v, $2v$, $3v$, $4v$, &c.

In order to give a synopsis of the results to which we have come, let AB be a column of fluid of the density D, expanding into a vacuum toward C. Let the velocity due to a height equal to one fourth of the subtangent of the fluid be v. Suppose expansion to have commenced at B, and the point of expansion to have receded to any distance n. Set off from B an infinite number of spaces Ba, ab, bc, cd, &c., each equal to Bn. Then the points n, B, a, b, c, d, &c., are the places of the points of expansion, and the boundaries of the several grades, or parts having different degrees of density and velocity, into which the original mass B*n* has been distributed.



Between these points respectively the densities are	$\frac{D}{2}$	$\frac{D}{4}$	$\frac{D}{8}$	$\frac{D}{16}$	$\frac{D}{64}$	&c.
The velocities are	v	$2v$	$3v$	$4v$	$5v$	&c.
These points move toward C with the velocities	$-v$	0	v	$2v$	$3v$	$4v$ &c.
and relatively to each other, and to the fluid, with the velocities	v	v	v	v	v	v

As corollaries from the preceding investigation we may state the following propositions.

1. No other gradations of density can exist in front of a column of fluid which is expanding towards a vacuum except those which are found by successive divisions of the original density by 2.

2. The change of density in the fluid in passing from one of these grades to the next is not *gradual*, but *instantaneous;* so that the grades are constantly separated from each other by a mere imaginary plane.

3. No other velocities can exist among the parts of a fluid which is expanding toward a vacuum but such as are multiples of the velocity which a body will acquire by falling through one fourth of the subtangent of the fluid.

4. The velocity imparted to the particles of an expanding fluid is not the result of a continual and gradual acceleration, but of successive instantaneous increments equal to that which a body will acquire by falling through one fourth of the subtangent of the fluid.

It now remains to consider the mode of expansion when the fluid is not free to expand indefinitely, but has its expansion arrested at some given density *d.*

It is obvious that if *d* correspond in value to any of the terms of the series, the manner of expansion up to that point will be the same as if the expansion were continued indefinitely. There will therefore be in the expanding fluid, in such case, so many grades corresponding to the terms of the series, as there are of complete terms intervening between D and *d.* But let us inquire what takes place when *d* does not correspond to any of the terms of the series. First, suppose *d* to be greater than the first term. Then from what has been before shown, the velocity of the point of expansion is that which a body will acquire by falling through $\frac{H-h}{2}$ when $H-h$ is the height of a column whose weight is equal to the elastic force of the expanded fluid; also that the velocity of the point of expansion is that due to the height $\frac{H}{4}$ when the expansion is from D to $\frac{D}{2}$. These velocities are as $\sqrt{\frac{H}{4}}$ to $\sqrt{\frac{H-h}{2}}$ and since $H : H-h :: D : d$, those velocities are as $\sqrt{\frac{D}{4}}$ to $\sqrt{\frac{d}{2}}$. The velocity due to $\frac{D}{4}$ is v. Hence we have $\sqrt{\frac{D}{4}} : \sqrt{\frac{d}{2}} :: v : v\sqrt{\frac{2d}{D}}$ = velocity of the point of expansion in this case.

Let us next find the velocity of the fluid. The times of running over s by the point of expansion, with the velocities $\sqrt{\frac{D}{4}}$ and $\sqrt{\frac{d}{2}}$ are inversely as these velocities; and the velocities imparted to the mass Ds in these times are as the products of the times by the respective forces. When the velocity of the point of expansion was $\sqrt{\frac{D}{4}}$ the force was $\frac{D}{2}$ and the velocity of the fluid was v. The force in the present case is $D-d$. Hence we have

$$\frac{\frac{D}{2}}{\sqrt{\frac{D}{4}}} : \frac{D-d}{\sqrt{\frac{d}{2}}} :: v : v\sqrt{2}\cdot\frac{D-d}{\sqrt{Dd}} = \text{velocity of the fluid in this case.}$$

Secondly, suppose the value of d to fall between any two consecutive terms of the series. It is obvious that we have now only to substitute in the expression last found that term of the series which is next greater than d for D, and it will then express the acceleration due to expansion from the last complete term into the fractional grade.

To find the retrogressive velocity of the point of expansion, relatively to the fluid, in the grade which precedes the fractional grade, we must make the like substitution of the last complete term for D in the quantity $v\sqrt{\frac{2d}{D}}$ found above. The retrogressive velocity of the point of expansion in the grade which precedes the fractional grade is greater than in the other grades, and of course that grade will be shorter than the others in the same ratio. This is the only modification which a fractional grade produces in those that precede it. In all other respects the mode of expansion, up to the fractional grade, corresponds to the view presented in the foregoing synopsis.

We are now prepared to construct a formula for the final velocity of a fluid which expands from any density D to any other density d.

Let V be the final velocity; v the velocity due to a height equal to one fourth the subtangent of the fluid; n the number of complete terms of the series $\frac{D}{2}, \frac{D}{4}, \frac{D}{8}, \frac{D}{16}$, &c., which intervene between D and d.

Then vn is obviously the velocity of the grade which precedes the fractional grade, if there be a fractional grade. When the first grade is fractional we found its velocity to be $v\sqrt{2}\cdot\frac{D-d}{\sqrt{Dd}}$; and we also found that to suit this expression to the case of a fractional grade occurring elsewhere in the range of the series, we are to substitute for D that term of the series which is next greater than d. Now the value of that term will be $\frac{D}{2^n}$. Making the substitution accordingly, the expression for the additional velocity due to expansion into the fractional grade becomes, after reducing, $v\sqrt{2}\cdot\frac{D-2^n d}{\sqrt{2^n Dd}}$. By adding this quantity to vn we obtain the final velocity of the fluid, resulting from its expansion from any density D to any other density d. Hence the formula is

$$V=v.\overline{n+\sqrt{2}\cdot\frac{D-2^n d}{\sqrt{2^n Dd}}}.$$

When there is no complete term of the series between D and d, $n=0$ and the above formula becomes $V=v\sqrt{2}\cdot\frac{D-d}{\sqrt{Dd}}$.

When there is no fractional grade, that is, when d is equal to some term of the series, that part of the formula beyond n equals 0, and then the above formula becomes $V=vn$.

From the general principles here developed it is obvious that, as in expansion, so likewise in *condensation*, the transition of an elastic fluid from one density to another is not by gradations which may be represented by a curve, but abrupt, instantaneous, *per saltum vel saltus*. Pulses, therefore, which are propagated in elastic fluids partake of the same character; that is, the condensation and subsequent reëxpansion of the successive elements through which the wave moves is instantaneous. This fact was not known when the article on the propagation of pulses, referred to at the commencement of this article, was written. It however does not affect the validity of the reasoning in that article.

XXXIV.—*On the Rotation of the Plane of Polarization of Heat by Magnetism;* by MM. F. de la Provostaye and P. Desains.*

Shortly after the brilliant discovery of Prof. Faraday of the rotation of the plane of polarization of light by magnetism, M. Wartmann announced† that he had tried the same experiment with radiant heat. He employed the heat of a lamp, which he partially polarized by making it pass through two piles of mica crossed at right angles. The electro-magnets and a cylinder of rock-salt were placed between these piles, and consequently very near the thermo-electric apparatus. The galvanometer, on the contrary, to be preserved from the action of the electro-magnets, was removed to a great distance; but the result was a considerable increase in the length of the circuit, and a diminution of sensitiveness.

Notwithstanding all these inconveniences, which he clearly pointed out, and which he was not able to overcome, M. Wartmann thought he observed that the needle of the galvanometer, after having attained a fixed deviation under the influence of the radiation not intercepted by the piles of mica, was again displaced and took a fixed position different from the first when the current was established, which seemed to indicate a rotation of the plane of polarization of heat.

At Paris, some persons having vainly attempted to reproduce these phenomena, we have considered that it would be useful to revert to these experiments, and to point out a method which permits of making them succeed with facility.

We have introduced into M. Wartmann's process three principal modifications:—1st, we employ solar heat; 2ndly, we take for polarizing apparatus two prisms of achromatic spar; 3rdly, and this appears to us indispensable, instead of placing the principal sections at 90°, we arrange them so that they make an angle of nearly 45°.

The employment of spars and solar light permits of removing the electro-magnets to a great distance from the thermo-electric pile. With respect to the arrangement of the prisms, the law of Malus shows all the advantages which it presents. In fact, let us take for unity the deviation which the solar ray transmitted through the principal parallel sections would produce. The deviation, when the prisms form an angle of 45°, will be $\cos^2 45^\circ = \frac{1}{2}$. If the current is set in action, and it produces a rotation of the plane of polarization equal to δ, the deviation will be, according to the direction of the current, $\cos^2(45^\circ-\delta)$ or $\cos^2(45^\circ+\delta)$, and we shall then have, for the difference of the effects observed when the current is made to pass in a contrary direction,

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* From the Annales de Chimie et de Physique, October, 1849,—cited from Phil. Mag., xxxv, 481.

† Institut, May 6th, 1846, No. 644.

$$\cos^2(45^\circ-\delta)-\cos^2(45^\circ+\delta)=\sin 2\delta.$$

On placing the principal sections at 90°, the difference of the deviations would be only

$$\cos^2(90^\circ-\delta)-\cos^2 90^\circ=\sin^2\delta,$$

or

$$\cos^2(90^\circ+\delta)-\cos^2 90^\circ=\sin^2\delta.$$

Now $\sin^2\delta$ is considerably less than $\sin 2\delta$. If, for example, we suppose $\delta=8^\circ$, $\sin^2\delta$ is equal to more than fourteen times $\sin 2\delta$.

The eye, it is true, appreciates readily the transition from darkness to light, but not so the difference in brightness of two luminous images. This is not the case with the thermoscopic apparatus. There is therefore, when heat is concerned, a great advantage in proceeding as above directed.

The following are the details of the experiment: the solar ray, reflected by a heliostat, traverses at first a doubly-refracting achromatic prism. The extraordinary bundle was intercepted: the ordinary bundle traverses the electro-magnet of M. Ruhmkorff's apparatus, and a flint-glass of 38 millimetres in thickness between the poles of the electro-magnet. It afterwards encounters, at about $3^{m}\cdot50$, the second prism of spar, bifurcates again, and gives two images, one of which may be received on the thermo-electric pile placed at four metres from the electro-magnet. The galvanometer was still a little further removed from this disturbing force. It was ascertained, by direct and repeated experiments, that on establishing the current there were no phenomena of induction, and that the electro-magnets had no appreciable action on the magnetic needle which, under their influence, remained at zero in a state of perfect rest. In order to understand this, it must be borne in mind that the two opposite poles are very close together, and that they act simultaneously upon a system already very distant and almost completely astatic. It might be feared that the electro-magnet, without action on the needle at zero, acted on the needle already displaced by the action of the calorific radiation. This would be possible in fact, if, in its first position, the needle had the same direction as the line which joins its centre to the electro-magnet, and if, when it deviates, it made a notable angle in that direction. In our experiments, precisely the inverse condition was realized; so that the component of the magnetic action diminished more and more during the movement of the needle, and became perfectly null when it attained its greatest deviation. If therefore it had no action in the first case, such ought for a stronger reason to be the case in the second.

By means of a commutator the electric current could be made to pass, now in one direction, now in another, through the wires of the electric magnet. We shall designate the two currents by the abridged expressions *Current* A, *Current* B.

The following are the deviations observed:—

Experiments of September 22.

(A Muncke's battery of 50 elements with large surfaces, but already worn, was employed.)

FIRST SERIES.

	Deviations.
Current A,	21·0
Without current,	19·0
Current A,	21·4
Without current,	18·6

SECOND SERIES.

(Acid was added.)

Without current,	20·5
Without current,	20·6
Current B,	18·6
Without current,	20·9
Current A,	23·6
Current B,	18·8
Current A,	22·0
Current B,	18·0
Without current,	19·9

THIRD SERIES.

Current B,	17·4
Current B,	17·1
Current A,	19·5
Without current,	18·3

Experiments of September 29.

(A Bunsen's battery of 30 elements, well-cleaned and amalgamated, was employed.)

FIRST SERIES.

	Deviations.
Without current,	12·0
Current A,	14·9
Current B,	8·6
Without current,	11·7
Current B,	8·8
Without current,	11·8

SECOND SERIES.

	Deviations.
Without current, ...	18·4
Current B, ...	14·9
Current A, ...	21·7

It is to be remarked, that here, if the principal sections of the prisms were perpendicular, the deviation, at first null, would scarcely attain one semi-division when one of the currents was made to act.

Lastly, to obviate every objection, a third series of experiments was made by taking away the prism of flint-glass, and observing the deviations produced by the solar ray, when, as before, the electric current was made to pass in the wires of the electro-magnet, now in one direction, now in another.

	Deviations.
Current A . . .	16·5
Current B . . .	16·8
Current A . . .	16·8

As should be the case, the deviations are equal, which proves that the electric current and the magnet change the deviations in acting on the flint-glass and not in acting on the needle of the galvanometer.

The above experiments establish, we believe, in an irrefragable manner, the rotation of the plane of polarization of heat under the influence of magnetism.

Art. XXXV.—*Historical account of the Eruptions on Hawaii;* by James D. Dana.*

The island of Hawaii has a nearly triangular outline with the three sides fronting severally, west, southeast, and northeast. The western side is about 85 geographical miles in length, the southeast 65, and the northeast 75 miles. The whole surface pertains to the slopes of three lofty volcanic summits, Mount (or Mauna) Loa† constituting its southern portion, 13,760 feet in height, Mount Kea, long extinct, covering the northern portion, 13,950 feet in height, and Hualalai towards the western shores, estimated at 10,000.

The voyager approaching Hawaii, while admiring the sublimity of its swelling heights, is struck with the unbroken surface of the island. Lofty peaks and alternating valleys and ridges are so generally characteristic of mountain scenery, that he views the even and gentle slope of the summits Loa and Kea with a degree of amazement. The former rises with a scarcely perceptible inclination, (see annexed cut,) without a break in the surface apparent in the distant view; then gradually rounds over, and declines on the opposite side with the same gentle declivity. The eye following along, up and down the sides of Mount Kea, meets with the same slopes, and only few traces of indentations. Mount Loa is a flat dome. Mount Kea rises to the same altitude, and differs only in having the summit somewhat pointed.

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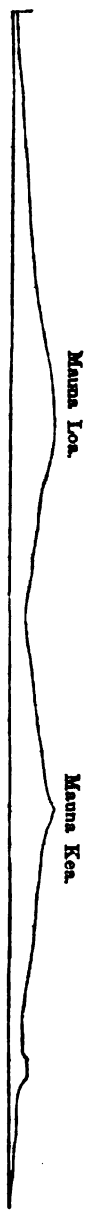
* Extracted and condensed from the Author's Exp. Expd. Geological Report.

† This name is often written *Roa*. L and r are interchangeable letters in the Hawaiian dialect. The l sound is most common, and is adopted in the written language of the islands.

From these descriptions the statement will be appreciated that the heights of Hawaii are not peaks in a mountain range, but three isolated domes or low cones, united by a confluence of lavas at base. The surface of the island is not a mass of broken mountains, but the simple slopes of these elevations. Yet on an actual scramble over the sides, there are found extensive ravines and ridges of lava which impede the progress; and numerous craters form large elevations usually ranging between three and nine hundred feet in height. There are also numerous gorges on the eastern and northern foot of Kea, which extend from the sea half-way up the mountain, and are from three hundred to a thousand feet in depth. The Kohala range on the north, which is the only part not conformable to this system, faces the interior of the island with a nearly vertical front, while northward the slopes are less abrupt and are profoundly intersected by valleys.

Mount Kea has an average slope of 7° 46′. The slope of Mount Loa on the south averages 7° 33′; on the west 5° 28′; on the east, to Kilauea, (a distance of 19·8 miles from the axis,) 6° 42′; making 6° 30′ the average for the dome. From Kilauea to the sea, the slope averages but 1° 28′, equivalent to 135 feet to the mile. The following map of a part of Hawaii* will assist in conveying an idea of the form of Mount Loa, the position of the crater at summit, and of Kilauea on its east-southeastern flank, 3970 feet above the sea.

We may hence assume 6° 30′ as the average inclination of the great dome. This gives for the base of the dome a breadth of forty-five and three-fourths miles. This however is only the central portion of the mountain: for the slopes spread very much below,


OUTLINE VIEW OF HAWAII, FROM THE EASTWARD.

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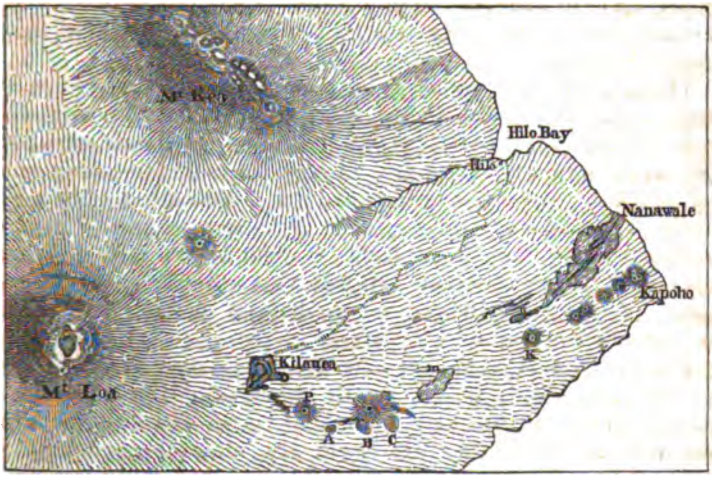
* This map is reduced from the chart published with the Narrative of the Expedition.

diminishing eastward to a single degree, so that the region of volcanic action subordinate to Mount Loa, is about seventy miles in width, or includes the entire breadth of the island, from east to west. The main part of the mountain, if considered a portion of a great sphere,* will correspond to a segment 13,760 feet deep, cut from a globe four hundred miles in diameter; or in form, to a segment about one-twelfth of an inch deep from a globe twelve inches in diameter: and in such a segment as last referred to, the terminal crater would be represented by an indentation one-fifteenth of an inch broad, and Kilauea by another one-tenth of an inch broad; and both about a fifteenth of their breadth in depth. The dome, consequently, instead of having slender walls at top, has a horizontal thickness of full twenty miles, eighteen hundred feet vertically below its summit.†



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* It varies a little from a segment of a sphere, the upper parts being slightly more prominent.

† For comparison with other lofty volcanic mountains we here mention a few other inclinations, as determined in different instances.

The peak of Teneriffe has an average inclination of 12° 30′, the proportion of height to diameter being given as 1 to 9.

Etna, according to Elie de Beaumont, has an average inclination of 8 degrees. M. von Buch makes the ratio of height to circumference as 1 to 34, giving the angle 10½ degrees. The Chimborazo dome, according to Humboldt, is only 673 toises through at a level of 153 toises (or 978 feet) below the centre of top.

It is much to be regretted that artists, when sketching mountains, are not content with giving them their actual slopes instead of attempting improvements by straightening up their sides, and sharpening their summits. Even in works of science, the same errors are common. We never see a drawing of Jorullo, which does not give the peak actually impossible slopes, taking Humboldt's own facts as a criterion. Drawings of Vesuvius and Etna, in the most prominent of our geological treatises, are equally objectionable. A simple outline, if correct, gives reliable information; and is far more valuable to science, than one improved to suit the fancy, though sketched with the skill of a master.

The two craters of Mount Loa are still active. The summit crater, called Mokua-weo-weo, measuring 13,000 and 8000 feet in its diameters, has a depth of 784 feet along its western precipice. Kilauea, the crater of most renown, is marked by no conical elevation; and the declivities of the parent mountain hardly vary in this part from a plain. Like Mokua-weo-weo it is a pit-crater, with vertical sides of horizontally stratified basaltic rock or lava.

The traveller first perceives his approach to the crater in a few small clouds of steam rising from fissures not far from his path. While gazing for a second indication he stands unexpectedly upon the brink of the pit. A vast amphitheatre seven miles and a half in circuit has opened to view. Beneath a gray rocky precipice of 650 feet, forming the bold contour, a narrow plain of hardened lava, (the "black ledge,") extends like a vast gallery around the whole interior. Within this gallery, below another similar precipice of 340 feet, lies the bottom, a wide plain of bare rock more than two miles in length.

The eye naturally ranged over the whole area for something like volcanic action, as it is usually described. But all was singularly quiet. In the dark plain that forms the bottom, there was little to attract attention beside the utter dreariness of the place, excepting certain spots of a blood-red color which appeared to be in constant yet gentle agitation. Instead of a sea of molten lava "rolling to and fro its fiery surge and flaming billows," we were surprised at the stillness of the scene. The incessant motion in the blood-red pools was like that of a cauldron in constant ebullition. The lava in each boiled with such activity as to cause a rapid play of jets over its surface. One pool, the largest of the three then in action, was afterwards ascertained by survey to measure one thousand five hundred feet in one diameter, and a thousand in the other: and this whole area, into which the Capitol grounds at Washington might be sunk entire, was boiling, as seemed from above, with nearly the mobility of water. Still all went on quietly. Not a whisper was heard from the fires below. White vapors rose in fleecy wreaths from the pools and numerous fissures, and above the large lake they collected into a broad canopy of clouds, not unlike the snowy heaps or cumuli that lie near the horizon in a clear day, though changing more rapidly their fanciful shapes. On descending afterwards to the black ledge, at the verge of the lower pit, a half-smothered gurgling sound was all that could be heard from the pools of lava. Occasionally there was a report like musketry which died away, and left the same murmuring sound, the stifled mutterings of a boiling fluid.

Such was the general appearance of Pélé's pit in a day view, at the time it was visited by the author.*

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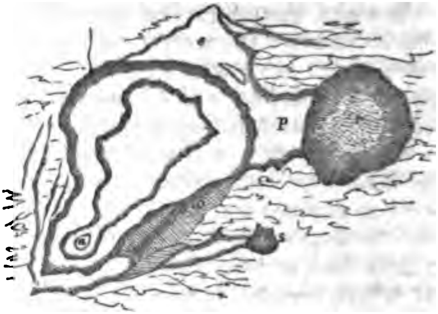
* In November, 1840.

At night, though no less quiet, the scene was one of indescribable sublimity. We were encamped on the edge of the crater, with the fires full in view. The large cauldron, in place of its bloody glare, now glowed with intense brilliancy, and the surface sparkled with shifting points of dazzling light, occasioned by the jets in constant play. A row of small basins on the southeast side of the lake were also jetting out their glowing lavas. Two other pools in another part of the pit tossed up their molten rock much like the larger cauldron, and occasionally burst out with jets forty or fifty feet in height. The broad canopy of clouds above the pit which seemed to rest on a column of wreaths and curling heaps of lighted vapor, and the amphitheatre of rocks around the lower depths, were brightly illumined from the boiling lavas; while a lurid red tinged the distant parts of the inclosing walls and threw into deeper shades of darkness the many cavernous recesses. And over this scene of restless fires and fiery vapors the heavens by contrast seemed unnaturally black, with only here and there a star like a dim point of light.

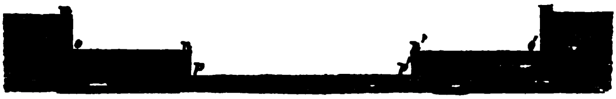
The next night streams of lava boiled over from the lake, and formed several glowing lines diverging over the bottom of the crater. Towards morning, there was a dense mist, and the whole atmosphere seemed on fire. The lakes were barely distinguished through the haze, by the spangles on the surface that were brightening and disappearing with incessant change.

We have endeavored to describe these views, with literal correctness. We are not responsible for any disappointment the account may create, as we could see only what was actually before us. Pele was in one of her sober moods. Yet we have reason to believe that this is her usual state, and assuredly there is a terrible grandeur even in her quiet. The action when most roused has been much exaggerated in its character; for boiling and overflowing, with occasional detonating explosions, constitute in every condition the characteristic features: in its greatest violence, the cauldrons are more numerous and extensive, the spouting cones multiply in number, the explosions are loud and frequent, and the sheets of lava at each overflow spread through the whole crater. Such a scene over an area seven and a half miles in circuit, must be terrific beyond description, although the "sea" be no sea; and the "waves" but the agitations of violent ebullition and frequent overflowings.

The accompanying bird's-eye view of Kilauea, reduced from the surveys of the Expedition, shows its oblong-ovate form and general features, though giving no adequate idea of its magnitude. The longest diameter lies nearly northeast and southwest, and is sixteen thousand feet in length; the average breadth is seven thousand five hundred feet. The pit includes, therefore, an area of nearly four square miles,* thus exceeding in extent many a city of one hundred thousand inhabitants. Yet on looking into it from above, it is difficult to realize its size, as there is no object within or about it which can serve for comparison. No one would imagine that two hundred such structures as St. Peter's at Rome could be accommodated within its walls, or that the lofty dome of this cathedral would stand with its pinnacle but little above the black ledge. The great lake of boiling lava (*a*), 1000 feet by 1500, as above mentioned, is a small object in such an area.



A better idea of the internal form of the pit will be obtained from a transverse section here represented. It is taken in the line of the shorter diameter; a section through the longer diameter on the same scale (a third of an inch to a thousand feet) would not have room on the page; *m m′* is the whole breadth of the crater; *o n*, *o′ n′*, the black ledge; *p p′* the bottom of the lower pit; *n p*, *n′ p′* the walls of the lower pit, 342 feet in height; *m o*, *m′ o′*, the walls above the black ledge, 650 feet in height.



VERTICAL SECTION OF KILAUEA.

The walls of the crater (*m o*) are vertical, or nearly so, through the most of their circuit. There is a break with several fissures in the northeast corner, (in the figure above, the *upper* side is *north*,) where is the usual place of descent; and on the southeast side (*o*) there are two or three sloping declivities, on which one of the famous sulphur banks is situated.

Without continuing with these details relating to the crater of Kilauea, we proceed to an account of the eruptions of which we have knowledge.

The first eruption of this crater of which tradition gives any definite knowledge, occurred about the year 1789, during the wars and conquests of Ka-meha-meha. It took place between Kilauea and the sea in a southeasterly direction. It is said to have been accompanied by violent earthquakes and rendings of the earth: and an eruption of cinders and stones from the opened fissures. It was so violent and extensive that the heavens were completely darkened; and one hundred lives are supposed to have been lost. There are now, over a large area near Kilauea a few miles distant to the south and southeast, great quantities of a light pumice-like scoria, with stones and sand, which are believed to have been thrown out at this time.*

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* As nearly as can be ascertained from the map of the crater the area is three and two-thirds square miles, or 100,000,000 square feet.

The famous outbreak of lavas, in 1823, and the features of the crater after it, are described by Mr. Ellis in his Polynesian Researches.† A large tract of country in Kau, the southern district of Hawaii, was flooded, and the stream, where it reached the sea, as I am informed by Rev. Mr. Coan, was five to eight miles wide. The earth is said to have been rent in several places, and the lavas were ejected through the fissures, commencing their course above ground some miles south of Kilauea. There was no visible communication with the lavas of this crater at the time; but the fact of their subsiding some hundred feet simultaneously with the eruption is satisfactory evidence of a connection. The crater after the eruption, as described by Mr. Ellis,‡ had the same general features as when visited by the Expedition. The black ledge continued completely around the crater, and was "three or four hundred feet" above the bottom. The pit was, however, in a more active state: for the southwest and northern parts are represented as vast floods of lava, and there were fifty-one small cones with craters, twenty-two of which gave out vapors, and some ejected lavas. Ellis remarks that the crater appeared as if, a short time before, the lavas had been as high as the black ledge.

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* The following account of this eruption is from a "History of the Sandwich Islands," by Rev. I. Dibble, published at Lahainaluna (island of Maui) in 1843. It was taken by the author from the lips of those who were part of the company, and present in the scene. The army of Keoua, a Hawaiian chief, being pursued by Kamehameha, were at the time near Kilauea. For two preceding nights, there had been eruptions, with ejections of stones and cinders. "The army of Keoua set out on their way in three different companies. The company in advance had not proceeded far before the ground began to shake and rock beneath their feet, and it became quite impossible to stand. Soon a dense cloud of darkness was seen to rise out of the crater, and, almost at the same instant, the thunder began to roar in the heavens, and the lightning to flash. It continued to ascend and spread around until the whole region was enveloped, and the light of day was entirely excluded. The darkness was the more terrific, being made visible by an awful glare from streams of red and blue light, variously combined through the action of the fires of the pit and the flashes of lightning above. Soon followed an immense volume of sand and cinders, which were thrown to a great height, and came down in a destructive shower for many miles around. A few of the forward company were burned to death by the sand, and all of them experienced a suffocating sensation. The rear company, which was nearest the volcano at the time, suffered little injury, and after the earthquake and shower of sand had passed over, hastened on, to greet their comrades ahead, on their escape from so imminent peril. But what was their surprise and consternation, to find the centre company a collection of corpses. Some were lying down, and others were sitting upright, clasping with dying grasp their wives and children, and joining noses (the mode of expressing affection,) as in the act of taking leave. So much like life they looked, that they at first supposed them merely at rest, and it was not until they had come up to them and handled them, that they could detect their mistake." Mr. Dibble adds, "A blast of sulphurous gas, a shower of heated embers, or a volume of heated steam, would sufficiently account for this sudden death. Some of the narrators who saw the corpses affirm, that though in no place deeply burnt, yet they were thoroughly scorched."

† Polynesian Researches, vol. iv., p. 211.

‡ Mr. Ellis, and many that have followed him in describing Kilauea, make much use of the word "flames," as though flames were actually seen. It is an excusable mistake, where the scenes are so startling and so far beyond description. An account appeared in a public print at Honolulu, about the time of the arrival of the squadron, in which "flames" were called in to give vividness to the description. It is needless to say that none were seen there by the writer, although the condition was the same as for the month previous.

In June, 1832, an eruption took place both from Kilauea and the summit crater of Mt. Loa. The only eruption, at this time, of the lavas of Kilauea to the surface, of which we have definite account, occurred in the east wall of the crater. A deep fissure was opened in the wall, (near *p*, figure on page 352,) from which streams flowed out, part back into Kilauea down the steep slope, and part across into the "Old Crater" (*r*), which, at the time, was overgrown with wood. It is important to trace out, as far as we are able, the changes which preceded it.

a. The first published account of the crater subsequent to Ellis's, is that of the Rev. C. S. Stewart, who visited it in July, 1825.[*] He states that it was nearly in the condition represented by Ellis in 1823. The bottom was several hundred feet below the level of the black ledge. Fifty-six conical craters were counted, and the action was violent and noisy. A plan of the crater at this time, by Lieutenant Malden, is given by Byron. The black ledge is represented as very much narrower than at present, so that the lower pit occupied nearly the whole width of the crater: the height of the ledge is stated at four hundred feet. The plan represents numerous cones over the bottom, and the two largest occupy together the whole transverse diameter of the crater, which would give for each a diameter of three thousand feet or more at base.[†]

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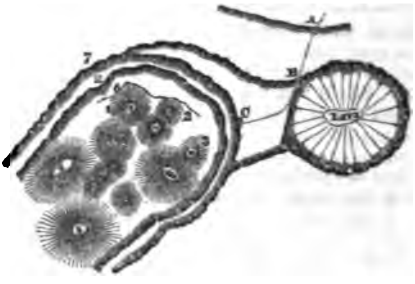
[*] Journal of a Voyage to the Pacific Ocean, and Residence at the Sandwich Islands, in the years 1822–1825, by C. S. Stewart; 12mo, 1828. New York. p. 355.



[†] A reduced copy of Lieutenant Malden's plan is annexed, as it will give increased interest to the facts observed by the Expedition. A, is a cliff of eighty feet; B, a cliff of one hundred and fifty feet; C, Lord Byron's encampment; E, the point on the black ledge where they descended to the bottom; 1, the crater in action visited by Lord Byron; 2, a sulphur cone; 3, crater that broke out at the time of the visit, 29th of June; 4, crater brilliantly in action; 5, the largest crater; 6, a deep fissure; 7, deepest and most precipitous part of crater. The whole crater is not represented. The largest cone (5) is nearly half the diameter of the lower pit, and must have been three or four thousand feet in breadth.

b. In December of the same year, Rev. A. Bishop observed that the crater had filled up much since the visit he made with Mr. Ellis, and he estimates the amount of change as four hundred (?) feet. There were a large number of cones "fifty to one hundred feet high," besides lakes boiling with much agitation, "every now and then sending forth a gust of vapor and smoke, with great noise." He adds, "the natives remarked that after rising a little higher the lava will discharge itself, *as formerly*, towards the sea *through some aperture under ground*."*

c. In October of 1829, Rev. C. S. Stewart made a second visit to the crater, and found, as he states, that the lower pit, instead of being four or five hundred feet deep, as when he before saw it, was but two hundred feet. He remarked that it had filled up at least two hundred feet. It was more quiet than in 1825, but there were still several boiling lakes of lava, and some cones in great activity.†

d. In September of 1832, when the Rev. J. Goodrich visited Kilauea, the eruption had taken place ‡ He says that every thing had changed. The lavas, which previously had increased so as *to fill up to the black ledge, and fifty feet above*, about nine hundred [four hundred?] feet in all, had sunk down again nearly to the same depth, leaving, as usual, a boiling cauldron at the south end. The earthquake of *January preceding* had rent in twain the walls of the crater, on the east side, from top to bottom, producing seams from a few inches to several yards in width, from which the region between the two craters was deluged with lava. About half way up the precipice there was a rent a quarter of a mile in length, from which immense quantities of lava boiled out directly underneath the hut formerly occupied by the party of Lord Byron. The position of Byron's hut is seen at C, on the figure at the foot of the preceding page, and near *p*, on the figure on page 352.

From these accounts, it is probable that in addition to the ejections from the east wall, which are insufficient to account for the subsidence in the lower pit, there must also have been a subterranean outlet beneath the sea, as the native with Mr. Bishop had predicted. This elevation of the lava a thousand feet above the lower pit, with its discharge from the very wall of the crater, is worthy of special note.

The next eruption to that of 1832, was the one already referred to, that commenced on the 30th of May, 1840, the lavas of which, where they reached the sea, were in some places still hot when visited by the author in the November following.

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* Missionary Herald, xxiii, 53.

† Visit to the South Seas, 2 vols. 12mo. New York, 1831.—ii, 78.

‡ American Journal of Science, xxv, 199.

The only published accounts of the crater subsequent to that just mentioned by Mr. Goodrich, and previous to this eruption, are those of Mr. Douglass,* Captain E. G. Kelley, (from statements by Captains Chase and Parker,)† Count Strzelecki,‡ and Captain John Shepherd.§

a. Mr. Douglass was at Kilauea in January, 1834. The pit, by his measurements, was one thousand feet deep, and the black ledge and lower pit appear to have been in the same condition as when seen by Mr. Bishop. There was a lake of boiling lava in the north end, three hundred and nineteen yards in diameter, besides the large one in the south end. The movement of the lavas to the southward (a consequence of the ebullition) was estimated to have a velocity of three and one-fourth miles per hour.

b. Captains Chase and Parker visited the crater in 1838, four years after Mr. Douglas. At that time, as the sketch made by them on the spot indicates, the lavas had so increased that the lower pit was almost obliterated, the bottom having risen nearly to a level with the black ledge. This will be understood from the figure on page 352: all the bottom pit between *p n* and *p′ n′* had become filled up, by the successive overflowings, to within forty feet of the top, and over the four square miles of area, the fires were in great activity.[1] There were six boiling lakes of lava, and twenty-six cones from twenty to sixty feet high, eight of which were throwing out cinders and red hot lava. Standing by the side of one of these lakes, they looked down more than three hundred feet upon its agitated surface: "after a few minutes the violent struggle ceased, and the whole surface of the lake was changed to a black mass of scoria; but the pause was only to renew its exertions, for while they were gazing at the change, suddenly the entire crust which had been formed commenced cracking, and the burning lava soon rolled across the lake, heaving the coating on its surface like cakes of ice upon the ocean surge. Not far from the centre of the lake was an island which the lava was never seen to overflow." These interesting facts illustrate several points of special importance in volcanoes, viz. (1) The rapidity with which lava cools; (2) The frequent rise of temperature that takes place even in boiling lakes, arising from a new gushing from the source below; (3) the formation of clinkers, well compared to the breaking up of ice. From the account of Captain Kelley, it appears that the whole bottom of the crater was not in fusion. On the contrary, the greater part was black lava, over which they travelled to the brink of some of the pools;

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* Jour. of the Roy. Geog. Soc., vol. iv.

† American Journal of Science, xl, 117; with a drawing of the crater, which shows that the obliteration of the lower pit was nearly complete.

‡ Hawaiian Spectator, i, 436.

§ Athenæum, Nov. 14, 1840; Roy. Geog. Soc. of London, 1840. Captain Shepherd evidently misunderstood the mode of action at the crater.

yet at times floods of lava covered a large portion of the whole area. The pools were in violent agitation, and "hissing, rumbling, agonizing sounds, came from the depths of the dread abyss."

c. When seen by Count Strzelecki in the same year, it was still in the condition above described. There were six lakes, one, as he states, of 300,000 square yards area, and five of about 5,700 square yards each. The great lake was in violent action.

d. Captain Shepherd was at the crater, Sept. 16, 1839. There were "numerous small cones, twenty to thirty feet high," "lakes of molten matter in violent agitation," besides a "great lake," one mile long and half a mile broad. The party, (notwithstanding the activity, be it observed,) *descended into the crater*, and visited several of the cones and small lakes on their way to the great lake. This lake was in "violent ebullition," underwent constant changes of brightness, and in some places flowed on, "leaving ridges of scoria on the northern shore."

e. We learn from the natives, that, for a week previous to the outbreak, the whole interior was a fearful scene of fiery deluges and ejections. There was no black ledge; for the lavas, by their overflowings, since 1832, had not only filled up the central pit, but accumulated over the ledge, and all was one vast theatre of intense action. The mountain was thus charged. The pressure on the sides below from the lavas and confined vapors had become immense. As a natural consequence fissures opened, and the lavas were drawn off; the centre of the great pit consequently sunk down three hundred and fifty or four hundred feet, which was its condition when visited by us.

There was no great earthquake, no shaking of Mount Loa. At Hilo not the faintest rumbling was heard or felt; and only slight quiverings to the south. It was a simple tapping of the great cauldron, Kilauea; and after it, the crater became comparatively inactive. Its black hardened surface, and the one or two boiling pools which remained over the vast area, exhibited the subdued quiet of exhaustion.

The first appearance of the lavas at the surface occurred in a small crater called *Arare*, about six miles from Kilauea, A, (map on p. 349,) as was ascertained soon after by the Rev. T. Coan.* The light was seen at a distance; but there were no inhabitants living in that vicinity, and it was set down for a jungle on fire. The next day another outbreak was distinguished farther towards the coast; and general alarm prevailed among the natives, now aware of the catastrophe in progress. Other openings followed, and by Monday, the first of June, the large flow had begun that formed a continuous stream to the sea, which it reached on the third of June, destroying the small village of Nanawale. This flood issued from several fissures along its whole course, instead of being an overflow of lavas from a single opening; it started from an elevation of 1244 feet, as determined by Captain Wilkes, at a point twenty-seven miles distant from Kilauea, twenty-two miles from the first outbreak, and twelve from the shores. The interval between the first appearance of the lavas and this flood presents a few patches of ejections, and some steam fissures.

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* Missionary Herald, 1841, volume xxxviii, p. 283. The author was over the portion of the eruption towards the sea in November. Subsequently it was examined by Captain Wilkes, Mr. J. Drayton, and Dr. C. Pickering; and by means of their investigations a map of the region was made out.

The extent of these patches was not accurately ascertained. Dr. Pickering mentions one small one, just before the last outbreak; and another, much larger, (*n*) covering probably three or four square miles, was observed by him a short distance above. A still larger patch, (*m*) according to a native report, exists about half way from the "Big Crater" (C) and the last outbreak; while still another, on the same authority, was seen just north of the "Big Crater." It is very remarkable, as stated by Dr. Pickering, that the line of fracture and lava patches should have cut through a high hill just north of the "Deep Crater" (B), and thus avoided this large pit where it might have been supposed there would have been the least resistance to fracture. The natives state that the lavas rose to a height of three hundred feet in the pit-crater Arare, the first point of outbreak, and then sunk again when the next outbreak took place; and the appearance of scoria within the crater satisfied Dr. Pickering that the lavas had risen at the time to the height mentioned.

The scene of the flowing lavas, as affirmed by those who observed it, beggars description. As we learn from an eye-witness, the lavas rolled on, sometimes sluggishly, and sometimes violently, receiving at times fresh force from new accessions to the fiery stream, and then almost ceasing its motion. It swept away forests in its course, at times parting and enclosing islets of earth and shrubbery, and at other times undermining and bearing along masses of rock and vegetation on its surface. Finally it plunged into the sea with loud detonations. The burning lava, on meeting the waters, as Mr. Coan states, was shivered, like melted glass, into millions of particles, which were thrown up in clouds that darkened the sky, and fell like a storm of hail over the surrounding country. "Vast columns of steam and vapors rolled off before the wind, whirling in ceaseless agitation, and the reflected glare of the lavas formed a fiery firmament overhead. For three weeks this terrific river disgorged itself into the sea with little abatement. Night was converted into day on all eastern Hawaii. The light rose and spread like the morning upon the mountains, and its glare was seen on the opposite side of the island. It was distinctly visible for more than one hundred miles at sea; and at the distance of forty miles fine print could be read at midnight."

At three spots on the coast, probably over three opened fissures whence lavas issued, the sands continued to be thrown up, until as many rounded or nearly conical elevations were formed, the largest of which was found to be 250 feet in height, and the smallest about 150 feet. They consist of a finely laminated tufa, like tufa craters. The coast is said to have been extended nearly a quarter of a mile beyond its former limits.

TUFA HILLS, NANAWALE.

The stream, as it appeared in November, consisted in its different portions of all the kinds of lava tracts elsewhere observed. In some portions, especially the upper, there were fields of the smoother variety, (the pahoihoi,) with the usual ropings and twistings of the surface; and there were some miniature cones, a few yards in height, out of which the lavas spouted for a while after the rest had become quiet. Large tracts were covered with sand; and walking over them, the feet often broke through into steaming chambers, suggesting caution to the traveller. Other large portions consisted of clinkers, a fact which might have been inferred from the description given of the varying rate of the moving lavas. In some portions they were in huge angular blocks; in others in slabs laid with much regularity against one another. There were numerous caverns and fissures still sending up clouds of steam; and in many, the rocks were yet glowing within a few feet of the surface. A piece of paper was instantly ignited. Small sulphur-banks, with deposits of alum and other salts, were met with in several places.

The islets of forest trees in the midst of the stream of lava were from one to fifty acres in extent, and the trees still stood and were sometimes living. Captain Wilkes describes a copse of bamboo which the lava had divided and surrounded; yet many of the stems were alive, and a part of the foliage remained uninjured.* Near the lower part of the flood, the forests were destroyed for a breadth of half a mile either side, and were loaded with the volcanic sand; but in the upper part, Dr. Pickering found the line of dead trees only twenty feet wide. The lavas sometimes flowed around stumps of trees, and as the tree was gradually consumed, it left a deep cylindrical hole, sometimes two feet in diameter, either empty or filled with charcoal.† Towards the margin of the stream, these stump-holes were innumerable, and in many instances the fallen top lay near by, dead but not burnt. Dr. Pickering also states that some epiphytic plants upon these fallen trees had begun again to sprout. The rapidity with which lava cools is still more remarkably shown in the fact that it was found sometimes hanging in stalactites from the branches of trees; and although so fluid when thrown off from the stream as to clasp the branch, the heat had barely scorched the bark.

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* Narrative Exp. Expd., iv, 184.

† Similar facts to those here stated were observed by M. Bory de St. Vincent at the Isle of Bourbon.—*Voyage aux Isles d'Afrique*, 3 vols., 4to, Paris, 1804.

The waters of the sea were so much heated that the shores for twenty miles were strewed with dead fish.

From the period, thirty-six hours, which the lavas required to reach the sea, an average velocity of four hundred feet an hour is readily deduced, as stated by Captain Wilkes. Yet, as the lavas issued from various fissures along the course,* the result cannot be correctly compared to an *overflow* of fluid: it is rather the rate of progress of the eruption than of the motion of a flowing liquid.

The thickness of the stream of lava here described was estimated by Dr. Pickering as averaging ten or twelve feet. In some places it was not over six feet. The whole area, judging from the surveys, covers about fifteen square statute miles; and reducing to feet and multiplying by the depth, 12 feet, gives for the amount of ejected lava 5,018,000,000 cubic feet; to which, if we add for the previous ejections of the same eruption three more square miles it gives 6,023,000,000 of cubic feet for the whole amount of lavas which reached the surface.†

We have a still more accurate means of estimating the amount of lavas which passed from Kilauea, in the actual cubic contents of the emptied pit. The area of the lower pit, as determined by the surveys of the Expedition, is equal to 38,500,000 square feet. Multiplying this by 400 feet, the depth of the pit after the eruption,‡ we have 15,400,000,000 cubic feet for the solid contents of the space occupied by lavas before the eruption, and therefore the actual amount of the material which flowed from Kilauea. This is two and a half times the amount obtained from the estimated extent of the eruptions. The difference may be accounted for partly on the ground that fissures were filled as well as surfaces overflowed, and also that there may have been eruptions beneath the sea not estimated. This amount is equivalent to a triangular ridge eight hundred feet high, two miles long, and over a mile wide at base.

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* On this point we cite the following passage from the Narrative by Captain Wilkes, (iv, 184):—"There are many fissures along the whole line, as will be perceived by the dark places on the map. I feel confident that from each of these an ejection had taken place, and that the lava had in some cases flowed in a contrary direction to the general course of the stream."

† Allowing an average depth of but ten feet, the calculation would give for the whole amount 5,000,000,000 cubic feet.

‡ As the measurements of the Expedition were made eight months after the eruption, we have allowed somewhat for the increase during that time, and also for cavities emptied beneath the ledge.

The lava of the eruption is remarkable for the large proportion of chrysolite, amounting in some parts to nearly one half, and occurring in coarse grains often a fourth of an inch thick. It is consequently very brittle, slabs being easily shattered to pieces by a tap of the hammer. The sands of the seashore produced by the eruption, consist largely of this mineral mixed with black grains of the comminuted lavas. In the abundance of chrysolite the lava is very unlike that formed in the crater either previous or subsequent to the eruption.

The sand-hills are examples of elevations thrown up suddenly over fissures of eruption. They consist of tufa of a rusty yellow color, and are distinctly and finely laminated. The sea is already encroaching on them, and has exposed the regular stratification of the interior, showing a steep inclination of the layers outward. Not a trace of tilting took place in the rocks beneath; they are simple cones of eruption, formed of ejected cinders. The sands are said to have been thrown out from the centre of each hill, while in progress; yet there is now no cavity at top. It appears that the action of the molten lavas as they met the sea must have been like the effect from a furnace of melted glass plunged beneath water. There was a violent explosion and eruption of fragments and steam, which fell around the centre of action; and owing to the water which ascended and descended with them, the structure became laminated like the alluvium of a river. Thus three "Monte Nuovos" instead of one were thrown up at a single eruption. The yellow color of the tufa is owing to the action of the steam and water on the ferruginous cinders, reducing some part of the iron to a hydrate.

Since leaving the Sandwich Islands, I learn from the Rev. Mr. Coan that the crater has again been gradually filling up. In November, 1841, there was little action except in the great lake. In February, 1842, the same condition of things continued, with only an increased state of activity. In July, 1844, Mr. Coan was near when the large lake overflowed its margin on every side, spreading out into a vast sea of fire, filling the whole southern part of the crater as far as the black ledge on either side, and obliterating the outlines of the cauldron. Two deep fissures opened, one on either side under the black ledge, and nearly encircled the whole southern area. The precipitous sides of one were two hundred feet in depth. These fissures soon became filled with the flood that was pouring over from the lake; and in one place "it fell in a cascade of fifty feet, producing a scene of terrific sublimity." In a letter dated June 25, 1846, Mr. Coan states that "the great lake is intensely active most of the time. The repeated overflowings have elevated the central parts of the crater 400 or 500 feet since 1840, so that some points are now more elevated than the black ledge." In a letter written in the next month to a friend from Rev. Mr. Lyman, the crater is described as having the whole interior filled, with some parts of the centre standing 100 to 150 feet above the black ledge. The large lake was still the centre of greatest activity.

It appears then at the last mentioned date to have been nearly in the condition sketched and described by Captain Kelley in 1839, previous to the eruption of 1840, except that the action had not reached the same degree of intensity.

Through a letter from Lieut. Henry Eld, U.S.N., we learn that in the spring of 1849, the bottom of the crater was still as last reported, but more raised. Yet instead of an increase of action, the crater was unusually quiet. The lavas had subsided in the great lake and it seemed as if the fires were in process of extinction. The action was far less than in 1840, when Lieut. Eld was at the crater with the officers of the Exploring Expedition.*

We conclude at this time with a mention of one or two deductions from the facts mentioned.

1. *Frequency of Eruptions.*—The last three eruptions of Kilauea have taken place in a period of nineteen years, or with intervals of eight or nine years. Between the years 1789 and 1823, there may have been a season of comparative quiet, as we learn from the natives of no great eruption. This evidence, however, is by no means decisive. They say, in general terms, that eruptions have taken place during all their kings, and assert that the crater has been in action from time immemorial. It is quite possible that in the above mentioned interval, there were submarine eruptions, if not subaërial; and very probably, the latter also may have taken place. The statement of the native to Mr. Bishop that the lavas, after reaching a certain height, would flow out as *they had formerly done under the sea*, is evidence that they were aware of this mode of emptying Kilauea of its lavas. In six years after 1840, the lower pit was again filled, and since then an eruption has been looked for.

2. *Phases of Volcanic Action.*—There can be no truth, at least as regards Mount Loa, in the principle reasoned out at length, in an able article on volcanoes, by Bischof,† that the phases of volcanic action depend on water gaining access to the central fires of the globe; for the evidence is certainly conclusive that the main action of waters is comparatively near the surface.‡

The phases of volcanic action at Kilauea are as follows:—

The centres of action, when most quiet, are reduced to a single one, which occasionally overflows. This overflowing raises the bottom of the crater; the lavas continue to boil over, and go on accumulating, and elevating the area of action; the pressure is consequently gradually increasing; the action becomes after a while more intense, perhaps in part from the increasing pressure, and the increasing height to which vapors ascend before escaping; new centres of ebullition add to the effect; finally, after the bottom is raised 400 or 500 feet above its lower level, these centres are numerous, the ebullition is violent, the overflowings almost incessant;—at last the increased pressure, in addition to the force of rising vapors proceeding from the increased action, cause a rupture through the mountain's sides and the lavas flow out.

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* The papers have since reported an eruption, but I have not seen the report confirmed.

† *Natural History of Volcanoes*, by G. Bischof. Jameson's Edinburgh Journal, xxvi, 1839; American Journal of Science, xxxvi, 249, 250.

‡ We omit here the arguments on this point.

This is the history from a period of quiet to one of greatest activity. If the larger pool, after an eruption, should become crusted over, as happens with the smaller pools, the lava sinking far below the surface, there would seem to be a state of inactivity. But the same process going on, the surface would be gradually reached, and the work would be continued as above explained. This is mainly a result of the passage of vapors from below, inflating the lavas as they ascend, producing the appearance of ebullition, and occasioning thus the rising of the molten material, and the overflowings. The scoria is the froth of the surface still more inflated, like the scum on the surface of a boiling syrup. Lavas from fissures in Kilauea usually are not scoriaceous, while the overflowings of the lakes have a crust of scoria 4 to 10 inches thick.

To compare Kilauea with other craters, we must keep in mind this important point, proved by the absence of cinders in the crater, and the free ebullition there, that the lavas are remarkably liquid, while those of other craters are comparatively viscid. The ejections of the great lake of Kilauea are 60 feet in height, while those of Vesuvius during an eruption may be 10,000 feet; and this, though not a direct measure of their relative liquidity, is a consequence of it. With this principle in view, we may translate the language of Kilauea into that of Vesuvius or Etna. The phases of their craters may be of the same general nature, and be due to a similar mode of action, varied only by the simple fact of the greater or less viscidity of the lavas. There may be the same succession of effects with the same results; and periods of quiet and violent action may have the same mutual relations and dependence. We need look to no extraordinary influx of waters to occasion an eruption, as the eruption is a result of a progressive state of things, perhaps long in action. I do not here deny that such a paroxysmal influx of waters may at times take place, and has produced results. I urge only that they are exceptions; and that phases of quiet and violent activity would necessarily succeed one another without such intervention.

The same gradually acting cause will also produce occasional violent ruptures. For where the waters for a period find slow access to any centre of heat within the volcanic mountain beneath its cover of rocks, the vapors will gradually accumulate till the pressure breaks a way through the mountain, to give exit to the vapors together with the compressed lavas. The starting of a cork from a bottle of soda water and the escape of the liquid as well as carbonic acid gas, though a familiar incident, depends on a general principle, with regard to pressure, to which even the lavas of a volcano must be obedient. The sudden outburst of lavas through fissures in the very summit of the walls about Kilauea may be of this character. In many cases violent earthquakes should attend this mode of action.

Art. XXXVI.—*On the Chemical Equivalents and Notation of Laurent and Gerhardt;* by Charles Gerhardt.

(Translated for this Journal, from the Comptes Rendus des Travaux de Chimie, Jan., 1849, by T. S. Hunt.)

In commencing the fifth year of these Comptes Rendus, in which I shall have for the future, the collaboration of M. Laurent, I wish to recall the principal features of the notation which we adopt in our system, and which appears to us at the same time more simple and more precise than the dualistic method. * *

The numerical value of our symbols is for the *metalloids*, the same as in the notation of Berzelius, but for the *metals*,* it is only one half. Thus we write, H^2O, SO^2, SO^3, P_2O_5, CO, CO^2, etc.; HCl, HBr, NH_3, have likewise the same significance, as in the ordinary notation: but in the metallic combinations, the symbol of the metal has but one half the value assigned to it in the Berzelian formulas.†

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* Except for arsenic, antimony, bismuth and uranium, which have the same value as in the Berzelian formulas.

† It will be recollected that the notation of Berzelius as followed by the French chemists, differs a little from that generally employed by the English and German writers. Berzelius, from a consideration of their combining volumes, was led to admit that oxygen and hydrogen unite to form water in the proportion of 1 : 2, and consequently to write the formula of the compound, H_2O. In accordance with this, he divided also the equivalents of the so-called halogen elements, chlorine, bromine and iodine, and designated the atom of hydrochloric acid, corresponding to water, by $H_2\,Cl_2$; his equivalents of nitrogen, phosphorus, arsenic, antimony, etc., are also one half those of the English chemists, but while admitting the atomic composition of water to be H_2O, he conceived the true equivalent of hydrogen to be *a double atom*, and thus made H_2 equivalent with K, Zn, etc. MM. Gerhardt and Laurent have divided in the same way the equivalents of the metals proper, making H the equivalent of K, Zn, etc.—*Translator.*

Examples.	*Notation of Berzelius.*	*Our notation.*
Sulphuret of hydrogen,	H_2S	$S\,(H_2)$
Sulphuret of potassium,	$K\dot{S}$	$S\,(K_2)$
Chlorid of hydrogen,	$H_2\,Cl_2$	$Cl\,(H)$
Chlorid of potassium,	KCl_2	$Cl\,(K)$
Sulphuric acid,	SO_3, H_2O	$SO_4\,(H_2)$
Sulphate of potash,	$SO_3, K\dot{O}$	$SO_4\,(K_2)$
Bisulphate of potash,	$SO_3, KO+SO_3, H_2O$	$SO_4\,(HK)$
Sulphate of zinc and potash,	$SO_3, KO+SO_3, ZnO$	$SO_4\,(ZnK)$
Nitric acid,	N_2O_5, H_2O	$NO_3\,(H)$
Nitrate of potash,	$N_2O_5, K\dot{O}$	$NO_3\,(K)$

The principal difference consists in the notation of *salts*, which we regard as unital in their constitution, as systems in which the metal may be exchanged for another, without affecting the arrangment of the molecular structure. (We write generally the metal in parentheses.) According to this view, the *acids*, properly called, (the hydrated oxacids, and the hydracids,) are *salts*, in which the metal is represented by hydrogen; the oxyds and sulphurets have the same claim to the title of salts as the sulphates and nitrates. The so-called anhydrous acids we look upon as a peculiar class of bodies, (*anhydrids*,) which become acids by the fixation of the elements of water.

We farther assume that *one and the same body may have two or several equivalents*. According to us the idea of an *equivalent* implies that of a similarity of function, and it is known that one and the same element is often capable of playing the part of two or of several other very different elements; it may then happen that each one of these different functions corresponds to different proportions of the first element. On the other hand, we sometimes see different weights of the same metal, as, for example, iron, copper or mercury, replace the hydrogen of acids to form salts, which although containing the same metal, are different in their properties. The metals have then different equivalents. Some examples will make this important proposition more plain.

The ferrous and ferric sulphates are two salts which contain for the same quantity of oxygen and sulphur, different quantities of iron. If we express by $S=16$, the quantity of sulphur, by $O=8$ that of oxygen, and by $Fe=28$ the quantity of iron, we shall have,

$$\left.\begin{array}{lll} \text{Ferrous sulphate,} & SO_4\,Fe & = SO_3, FeO \\ \text{Ferric sulphate,} & SO_4\,Fe\tfrac{2}{3} & = 3SO_3, Fe_2O_3 \end{array}\right\}\begin{array}{l}\text{Berzelian}\\ \text{formulas.}\end{array}$$

Thus in the ferric sulphate there are but two-thirds the quantity of iron which exists in the ferrous sulphate; but these two-thirds of Fe are the equivalent of H, K, Na, Zn, etc., and also of the Fe in the ferrous salts; but when two-thirds of Fe replace H in sulphuric acid, or K in the sulphate of potash, we obtain a salt which without ceasing to be a neutral sulphate, possesses properties very different from those of the ferrous sulphate where Fe entire, replaces H, K, Zn. The equivalent $Fe_{\frac{2}{3}}$ then communicates to the sulphatic system properties as different from those of the ferrous sulphate, as would be those of a sulphate containing any other metal.

Again, in the mercurous and mercuric chlorids we have the same amount of chlorine united to different quantities of the metal.

$$\left.\begin{array}{ll}\text{Mercurous chlorid,} & Hg_2\,Cl_2\\ \text{Mercuric chlorid,} & Hg\ \ Cl_2\end{array}\right\}\text{Berzelian formulas.}$$

Hg_2 in the mercurous salts is the equivalent of H, K, Na, Pb, etc., and equally of Hg in the mercuric salts. Mercury has then according to our view, two equivalents (*mercuricum* and *mercurosum*), as compared with other metals, which are to each other as 1 : 2, and each one of these has its peculiar properties.

To show in the formulas that $Fe_{\frac{2}{3}}$, Hg_2, represent equivalents of H, K, Na, etc., we often replace the exponents by certain signs, employing the Greek letters α, β, γ, and δ, in place of the numbers 2, $\frac{2}{3}$, $\frac{1}{2}$, $\frac{1}{3}$. The equivalents of H in the following salts are then thus represented.

	$2 = \alpha$
Cu in the cupric salts.	Cu_2 or $Cu\alpha$ in the cuprous salts.
Hg " mercuric "	Hg_2 or $Hg\alpha$ " mercurous "
	$\frac{2}{3} = \beta$
Fe in the ferrous salts.	$Fe_{\frac{2}{3}}$ or $Fe\beta$ in the ferric salts.
	$Al_{\frac{2}{3}}$ or $Al\beta$ " aluminic "
Cr " chromous salts.	$Cr_{\frac{2}{3}}$ or $Cr\beta$ " chromic "
Mn " manganous "	$Mn_{\frac{2}{3}}$ or $Mn\beta$ " manganic "
	$\frac{1}{2} = \gamma$
Sn " stannous salts.	$Sn_{\frac{1}{2}}$ or $Sn\gamma$ in the stannic salts.
Pt " platinous "	$Pt_{\frac{1}{2}}$ or $Pt\gamma$ " platinic "
	$\frac{1}{3} = \delta$
	$Bi_{\frac{1}{3}}$ or $Bi\delta$ in the bismuthic salts.
	$Sb_{\frac{1}{3}}$ or $Sb\delta$ " antimonic "
	$Au_{\frac{1}{3}}$ or $Au\delta$ " auric "

Upon this plan of notation we write the formulas of these salts as follows:

	Berzelian notation.	*Our notation.*
Alum,	$SO_3, KO + Al_2O_3, 3SO_3 + 24$ aq.	$SO_4(K_{\frac{1}{2}}\,Al\beta_{\frac{3}{2}}) + 6$ aq.
Sulphate of potash,	SO_3, KO	$SO_4(K_2)$
Phosphate of soda,	$P_2O_5, 2NaO, H_2O + 24$ aq.	$PO_4(Na_2H) + 12$ aq.
Biphosphate of soda,	$P_2O_5, NaO, 2H_2O + 2$ aq.	$PO_4(NaH_2) +$ aq.
Phosphate of lead,	$P_2O_5, 3PbO$	$PO_4(Pb_3)$
Phosphate of alumina,	P_2O_5, Al_2O_3	$PO_4(Al\beta_3)$

The simplicity of the new notation is especially evident when applied to those salts which contain several metals, as in the natural silicates. Take for an example the formula of the chlorite of Slatoust, which in the notation of Berzelius is represented by

$$3MgO, SiO_3 + Al_2O_3, SiO_3 + 2(MgO, 4H_2O).$$

This we write,

$$SiO_3(Al\beta\tfrac{3}{3}\,Mg\tfrac{5}{3}\,H\tfrac{4}{3}),$$

and this formula reminds us at once that chlorite belongs to the silicates of the form $SiO_3(M_4)$,* for $\frac{3}{3}+\frac{5}{3}+\frac{4}{3}=4$.

The advantage of our notation consists then principally in this, that it expresses all the salts of the same genus in the same manner; each symbol appears but once in a formula. Consequently *we denote similar compounds in a similar manner.*

In the notation of organic substances, we take their volumes into consideration, when they are bodies which are volatile without decomposition. We denote these always by the same number of volumes, and the non-volatile compounds derived from them by similar formulas. Thus for the monobasic acids, we take as an equivalent the quantity which contains (H) one equivalent of basic hydrogen; this corresponds to two volumes of vapor. The derivatives (*non binômes,*) which do not perform the functions of salts, are represented by the same number of volumes; in case these derivatives are fixed, we take as an equivalent the quantity produced by one equivalent or yielding one equivalent, of the monobasic acid. For example,

	Berzelian notation.	*Our notation.*
Acetic acid, . .	$C_4H_6O_3, H_2O$	$C_2H_3O_2(H)$
Acetate of potash,	$C_4H_6O_3$, KO	$C_2H_3O_2(K)$
Ferric acetate, . .	$3C_4H_6O_3, Fe_2O_3$	$C_2H_3O_2(Fe\beta)$
Chloracetic acid, .	C_2O_3, C_2Cl_6, H_2O	$C_2Cl_3O_2(H)$
Chloracetate of potash, .	C_2O_3, C_2Cl_6, KO	$C_2Cl_3O_2(K)$
Ferric chloracetate,	$3(C_2O_3, C_2Cl_6), Fe_2O_3$	$C_2Cl_3O_2(Fe\beta)$
Alcohol, . . .	C_2H_6O	C_2H_6O
Aldehyde, . . .	$C_4H_8O_2$	C_2H_4O
Olefiant gas, . .	CH_2	C_2H_4

The bibasic acids not being volatile without decomposition, the law of volumes cannot be applied to them directly, but these acids give by decomposition, volatile anhydrids. We take then as the formula the quantity which yields two volumes of an anhydrid. These acids are therefore represented with two equivalents of basic hydrogen (H_2). Examples.

	Berzelian notation.	*Our notation.*
Oxalic acid, . .	C_2O_3, H_2O	$C_2O_4(H_2)$
Oxalate of potash,	C_2O_3, KO	$C_2O_4(K_2)$
Binoxalate of potash,	$C_2O_3, KO + C_2O_3, H_2O$	$C_2O_4(HK)$
Quadroxalate of potash, . .	$C_2O_3, KO + 3(C_2O_3, H_2O)$	$C_2O_4(H\frac{3}{2}K\frac{1}{2})$

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* We write silica SiO; $(SiO, 2M_2O, = SiO_3(M^4))$.

In the same manner the tribasic acids are denoted with three equivalents of basic hydrogen, (H_3,) as in the following examples.

	Berzelian notation.	*Our notation.*
Citric acid, . .	$3C_4H_4O_4,2H_2O$	$C_6H_5O_7(H_3)$
Acid citrate of potash,	$3C_4H_4O_4,KO+H_2O$	$C_6H_5O_7(KH_2)$
Second citrate of potash, . .	$3C_4H_4O_4,2KO$	$C_6H_5O_7(K_2H)$
Third citrate of potash, . .	$C_{12}H_{10}O_{11},3KO$	$C_6H_5O_7(K_3)$

By analogy we represent the mineral acids also with H, H_2 or H_3, according as they are monobasic, bibasic, or tribasic.

Most chemists denote organic substances by formulas which are double those adopted by us, but all these formulas, when they are exact, may be divided by two and represented in our notation.

I finish this introduction by a table of the proportional numbers of the principal simple bodies, with the numerical value that is ascribed to them in our notation.

		H=1.	O=100.			H=1.	O=100.
H	Hydrogen, .	1·	6·25	Cl	Chlorine, .	35·5	221·87
Li	Lithium, .	6·4	40·16	K	Potassium, .	39·	243·75
B	Boron, . .	10·8	67·50	Sr	Strontium, .	44·	275·00
C	Carbon, . .	12·	75·00	Cd	Cadmium, .	56·	350·00
Mg	Magnesium,	12·	75·00	Sn	Tin, . . .	59·	368·75
Al	Aluminium,	13·7	85·63	Sb	Antimony, .	64·5	403·25
N	Nitrogen, .	14·	87·50	Ba	Barium, . .	68·	425·00
Si	Silicon, . .	14·	87·50	As	Arsenic, . .	75·	468·50
O	Oxygen, .	16·	100·00	Se	Selenium, .	78·5	490·90
Fl	Fluorine, .	18·6	116·85	Br	Bromine, .	80·	500·00
Ca	Calcium, .	20·	125·00	W	Tungsten, .	96·	600·00
Na	Sodium, .	23·	143·75	Pt	Platinum, .	99·	618·75
Cr	Chromium, .	26·	162·50	Hg	Mercury,	100·	625·00
Fe	Iron, . . .	28·	175·00	Pb	Lead, .	104·	650·00
Mn	Manganese, .	28·	175·00	Ag	Silver, .	108·	675·00
Ni	Nickel, . .	29·6	185·00	U	Uranium,	120·	750·00
Co	Cobalt, . .	29·6	185·00	J	Iodine, .	126·	787·50
Cu	Copper, . .	31·8	198·75	T	Tellurium,	128·	800·00
S	Sulphur, .	32·	200·00	Au	Gold, .	196·	1225·00
P	Phosphorus,	32·	200·00	Bi	Bismuth,	210·	1312·50
Zn	Zinc, . .	33·	206·25				

Art. XXXVII.—*The Natural Relations between Animals and the Elements in which they live;* by L. Agassiz.

Among the early attempts to arrange animals in a systematic order, we find almost universally, that the natural elements in which their different tribes live are introduced as the fundamental principle of their classification. During the sixteenth and seventeenth centuries, the great works published upon natural history by Gesner, Rondelet, Belon, Aldrovandi and others acknowledge this as the only basis of their arrangement of the animal kingdom. Even at a later period, when characters derived from the animals themselves, rather than from the external circumstances in which they dwell, had been introduced into our systems, we still find a prevailing influence of such considerations upon the circumstances of the natural subdivisions of animals. As soon however as the study of comparative anatomy had shed its brilliant light upon this question, those views were entirely abandoned, and the whole animal kingdom was finally arranged according to its internal structure. The introduction of this principle was hailed as a new era in the history of our science; and, after Cuvier had applied it to a general revision of the whole animal kingdom, it was and has been universally acknowledged as the only safe foundation of a natural classification of animals.

The recent progress in zoology, and of the various branches of natural history connected with it, has however opened the prospect of further improvements, even upon the basis on which our classification at present rests. For embryology is already displaying its vast influence upon zoological questions, and the time is not far distant, when its share in the natural arrangement of animals will be as large as that of comparative anatomy itself, and when information derived from all possible quarters shall have equally its due influence upon our natural methods. A desire to investigate the various questions bearing upon classification has led me to revise the subject of the natural relations which exist between animals, and the elements in which they live. The connection between animals and the surrounding media in which they live has of late been so entirely disregarded, that it is time to reconsider this question with all the attention its importance demands, since we find in it a decided relation to the structure and functions of all animals. For though it is plain that the mere living in water or upon dry land is in itself of slight importance, as there are so many animals which dwell in the two elements although having the same *identical* structure, it should not be overlooked that the greater number of aquatic animals have structural peculiarities common to all, and that the same is the case with the terrestrial or aërial animals. For instance, all those which live upon dry land breathe directly the atmospheric air, and have a respiratory apparatus adapted for direct introduction of this element into their systems, while aquatic animals breathe through apparatus of a different structure adapted to a permanent contact with aërated water. This circumstance alone would suffice to show that the natural relations of animals with the elements in which they naturally dwell, is in direct connection with at least some of their structural peculiarities. But there are other circumstances which may lead to the conviction that this connection has not merely reference to the structure of their respiratory apparatus, but influences their whole organization. The greater pressure under which aquatic animals are maintained throughout their life modifies, in many other respects, their organization. In many of them the surrounding element has largely a direct access into the cavities of the body or even into their tissues; so that a direct and universal influence of the surrounding media must be acknowledged throughout the animal kingdom as soon as we take into consideration all their peculiarities. This influence will be appreciated more correctly, if we consider it separately in each great group of the animal kingdom as established upon anatomical evidence.

After removing the Whales from the Fishes, it will be plain that the Cetacea must be considered simply as an aquatic type of the class of Mammalia, and that the connection which exists between them and the element in which they live will not affect at all the views which we shall entertain about that class, and only allow us to consider within more natural limits, the true relation which exists between fishes and the natural element in which they are found. The circumstance that so many birds are aquatic in their habits will no longer prevent us from considering the class of Birds as a most natural group in the animal kingdom, the limits of which are well defined by anatomical evidence; and the relations of aquatic birds to the waters upon which they alight or in which they dive, will only be considered within the limits of a well circumscribed natural group. The same may be said of Reptiles; and the circumstance that so many of their types are almost entirely aquatic, while others are terrestrial, will by no means prevent us from viewing them as a natural class, in which the connection with either main land or the water shall appear as a subordinate feature.

Again the class of Insects, which is so thoroughly aërial throughout almost all its types, at least in their perfect state of development, circumscribed as it is within natural limits upon anatomical evidence, will appear to us as a type which shall bear no relation in our mind to the class of Birds, although their movement through the atmosphere be apparently so similar.

But, although we remove in this manner almost completely the circumstance of animals dwelling either in water or upon main land as influencing in any way our general classification of the animal kingdom, it were a great mistake to lose sight entirely of this most intimate relation among the natural secondary groups of animals under their different types.

The value of these considerations has become more apparent, since the outlines of the leading divisions in the animal kingdom have been made in detail by allowing the results of embryology to have their due share of influence upon our classification; and the object of these remarks is chiefly to show that there is a universal relation throughout the animal kingdom between their structure and gradation and the elements in which they live; that, in all the four great types of the animal kingdom, the aquatic groups stand, in natural classification, lower than the terrestrial, and that this connection is so intimate as to extend even to the subdivisions, and so much so, that I have arrived at the conviction that in an otherwise well defined natural division, the aquatic tribes should be placed below the terrestrial ones; that even in narrowly circumscribed families the aquatic genera rank below the terrestrial, and that even in natural genera the aquatic species are inferior to the terrestrial ones. But before considering those minor divisions let us take a general glance at the four great types of the animal kingdom beginning with the Radiata.

If we consider the type of Radiata as it is still circumscribed in some of our most recent works upon the animal kingdom in general, we may fail to discover this intimate connection between their natural types and the media in which they live. But if we reduce the type of Radiata to those classes which I consider as alone truly representing that type, we shall be at once struck with the remarkable result, that all these animals are aquatic, nay, that, with one single exception, they are all marine. But before this can be acknowledged, it must be shown that the type of Radiata should be reduced to the three classes of Polypi, Jelly-fishes and Echinoderms; and that, among Polypi, there are large numbers of animals now united which do not all belong to that class. The most extensive range acknowledged by some zoologists in the type of Radiata includes Infusoria with the Rotifera and also intestinal worms. Without entering for the present into a full discussion of the natural character of all the animals which have been included in the class of Infusoria, I may limit my remarks to a few critical points, in order to show that the Polygastrica, and even the Rotifera cannot be ranked among Radiata.

In the first place Rotifera constitute a particular group among Infusoria as Ehrenberg himself has acknowledged. They differ so completely from the Polygastrica as to forbid entirely their union in a natural classification. The only question is whether they can remain among Radiata, and, if not, where they should be placed. There is so little analogy between the structure of Rotifera and the structure of true Radiata, that ever since the beautiful illustration of their forms and structure as given by Ehrenberg, most naturalists and anatomists have felt inclined to remove them to another type of the animal kingdom. Their resemblance to Articulata has appeared to some so striking as to warrant, in their opinion, their removal to the class of Crustacea, among Entomostraca, while others have considered them as more closely allied to worms. But I may say that all, or almost all, naturalists at present understand the necessity of removing them from among Radiata into the great type of Articulata.

This point is no longer in question; the only remaining doubt respecting them is whether they should rank among the lower Crustacea, or among the worms in the wider sense. As for the Polygastrica, we meet with greater difficulties in attempting to classify them; for this group, as understood by Ehrenberg, consists still of most heterogeneous beings which do not even all belong to the animal kingdom. Recent investigations upon the so-called Anentera, including the families of Baccillaria and Volvocine Infusoria, have satisfactorily shown, in my opinion, and in that of most competent observers, that this type of Ehrenberg's Polygastrica without gastric cavities, and without an alimentary tube, are really plants belonging to the order of Algæ in the widest extension of this group; while most of the Monas tribe are merely movable germs of various kinds of other Algæ. As for the other Polygastrica which Ehrenberg combines in this division of Enterodela, I am satisfied that they also constitute still a heterogeneous group belonging to different types of the animal kingdom; and that most of them, far from being perfect animals, are only germs in an early state of development. The family of Vorticellæ exhibits so close a relation with the Bryozoa, and especially with the genus Pedicellina, that I have no doubt that wherever Bryozoa should be placed, Vorticella should follow, and be ranked in the same division with them.

The last group of Infusoria, Bursaria, Paramecium and the like, are, as I have satisfied myself by direct investigation, germs of fresh water worms, some of which I have seen hatched from eggs of Planaria laid under my eyes. This being the case, we see that, without exception, the whole class of so-called Infusoria must be dissolved into its various elements and divided partly among the Articulata, and partly among Mollusca in the widest extension of those groups, (if it can be shown that Bryozoa belongs also to the type of Mollusca,) that large numbers of them belong to the vegetable kingdom, and others are simply germs of other types, and that no single one of them belongs to the type of Radiata.

If we next consider the Polypi we find them constituting another main group and most natural class, to which indeed some heterogeneous types have been annexed; upon the removal of these however that class constitutes a very natural division of the type of Radiata among which they form the lowest class. The natural groups which require to be removed from Polypi are, —first, the so-called Hydroid Polypi, which, though truly radiated animals, do not belong to this class, but are, as I have shown from their structure, and as might long ago have been inferred from their development, true members of the class of Medusæ, among which they constitute a type of stalk animals, as crinoids among star-fishes.*

The Bryozoa also are not constructed upon the plan of Radiata, as has long been shown by Milne Edwards and others. Their true position is among Mollusca, and embryonic investigations upon Ascidia have satisfied me that Bryozoa, compound, and simple Ascidia, form a natural series of well connected types leading to the true Acephala among ordinary Mollusca, among which Bryozoa will form a natural group of compound animals, bearing the same relation to the ordinary bivalve shells, that common corals bear to the simple Actiniæ and Fungiæ. Though the doubts entertained about the Foraminifera among Bryozoa, would not affect at all the points under discussion, I may as well state at once, that I have arrived at the conclusion that Foraminifera constitute the lowest type of Gasteropoda, and exemplify under permanent forms the state of division of their germs in their embryonic development. Thus circumscribed, the class of Polypi constitutes a very natural group containing only animals of an identical radiated structure, the organization of which is at present very satisfactorily known.

The class of Medusæ has been from the beginning so well characterized, and circumscribed within so natural limits, that it has undergone since its establishment only slight modifications by the removal of some few genera: and after the position of the so-called Hydroid Polypi among them shall have been generally acknowledged, I believe it will undergo scarcely any new changes in its extension, though we may still expect extensive improvements, which are indeed very much needed, in the characteristics and internal arrangement of their natural families. Considering their structure, the Medusæ rank immediately above Polypi.

The Intestinal Worms have long been placed among Radiata, and considered as a natural class in this great type of the animal kingdom, notwithstanding so many striking differences in the plan of their structure. This position was assigned to them upon the ground of the radiated arrangement of parts around the head, and the vascular form of some of their genera, and also upon the supposed want of a nervous system in all of them. But since the discovery of nerves in all of their types, and since the most intimate relations have been discovered between them and so many other external worms, their complete separation from Annelides as a distinct class is hardly recognized now by any modern investigator. And the necessity of combining the intestinal parasitic worms into one great natural group with the other external free worms is becoming daily more evident to all, so that whatever position be assigned to Annelides in the great type of Articulata, Helminths have to follow them, and must therefore be removed from the type of Radiata. This point is undisputed now, though there may be a difference of opinion as to the propriety of admitting, to one great class, all Worms, or of subdividing them into minor natural groups.

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* See my paper upon the homologies of radiated animals with reference to the classification of the so-called hydroid polypi, read before the American Association for the Advancement of Science, held in Cambridge, August, 1849; also my lectures upon comparative embryology, delivered before the Lowell Institute, Dec., 1848, and Jan., 1849.

The third class among Radiata is that of Echinoderms, which has been circumscribed within most natural limits since the reunion of Holothuriæ and Crinoids, with the common star-fishes and true Echini. Whoever is familiar with the embryonic development of Echinoderms, which has been extensively investigated of late, will acknowledge an intimate relation between them and the other two classes of Radiata, and not be willing to assent to the proposed separation of Echinoderms as one great type in the animal kingdom, placed upon an equal footing with Mollusca, and will consider their separation from Polypi and Medusæ, as proposed by Dr. Leuckardt, rather as a retrograde step, than as an improvement upon the general classification of animals. To me the type of Radiata, embracing the three classes of Echinoderms, Medusæ and Polypi, constitutes, in its circumscription illustrated above, a most natural group of the animal kingdom, all the members of which are intimately connected by a close uniformity in the plan of their structure, but present a remarkable gradation of their types in the manner in which this structure is developed in each of their classes. And the circumstance that even in the higher ones, which contain chiefly free movable animals, we have some few representatives attached permanently to the soil upon a Polyp-like stalk bearing the radiated animal crown, shows further the intimate connection which exists between them all. Radiata consist therefore of three classes only, which in their natural gradation rank as follows: Polypi, lowest, next, Medusæ, and highest, Echinoderms.

As soon as we have removed in this way all the classes or families which do not strictly belong to the type of Radiata, we cannot fail to perceive at once that all the remaining animals which must be considered as truly radiate are not only all aquatic, but, with a single exception of the genus Hydra, all strictly marine; from which we are allowed to infer that, in the plan of the creation, the radiated structure is incompatible with a terrestrial mode of life. We see that the lowest degree of development of the whole animal kingdom is entirely marine; and that it has been so throughout all ages in the history of our globe, is shown by the large numbers of Radiata found from the earliest periods through all geological epochs up to the most recent, and the entire absence of radiated animals in any of the fresh water deposits. The circumstance that no single genus among Radiata contains fresh water animals, further shows that this type in its main features is not better adapted for a fluviatile existence; or, we may say in other words, that the plan involved in the structure of radiated animals is chiefly adapted to the sea. We might perhaps even say, if, in this stage of the investigation, it would not seem premature to go so far, that the lower types of animals are not only entirely aquatic, but exclusively marine. The fact of so large a number of aquatic animals as Radiata being so exclusively marine, undoubtedly shows that the connection of organic structure with the ocean, involves peculiar circumstances, which fresh waters by no means afford to a similar extent. Whether this is especially connected with the greater density of the medium or not, I am not fully prepared to say, though I am inclined to believe that it is so, from the circumstance that Radiata are so constantly killed by the contact of fresh water, as I have ascertained by direct experiment upon Polypi, Medusæ and Echinoderms, some of which are struck with almost instantaneous death, when brought into fresh water, and decompose with astonishing rapidity. I have seen on dropping an Ophiura into fresh water, all the articulations dismembered and entirely separated within a few minutes.

No one of the three other great types of the animal kingdom is either so exclusively marine, or even so exclusively aquatic as that of Radiata. For among Mollusca we have quite a number of terrestrial genera, and even a large number of fresh water genera and families.

Among Articulata we notice also large numbers of fresh water species, and a still larger number of terrestrial forms. Finally, among Vertebrata we find the most promiscuous occurrence of marine, fresh water and terrestrial forms. It is now important to ascertain whether we may trace, beyond Radiata, a direct relation between structure and the element in which animals live, and whether the gradation of this structure has any reference to the surrounding media as it unquestionably has among Radiata.

Let us first consider Mollusca, and perhaps revise their classes in a zoological point of view before undertaking the investigation of their relations to the media in which they dwell, allowing in this revision, a due influence to embryology as far as it can influence this question at present.

The number of classes which should be admitted among Mollusca, is the first point of importance we have to consider. Since the Barnacles or Cirripedia which Cuvier still considered as a class among Mollusca, are now known to belong to the type of Articulata, and to be most conveniently combined with Crustacea, we have five classes of Mollusca left, if we follow Cuvier's arrangement of these animals, as he distinguishes Cephalopoda, Pteropoda, Gasteropoda, Acephala and Brachiopoda, as so many distinct classes of the type of Mollusca in the order of gradation just mentioned. It will hardly be necessary at present to insist upon the close relation which exists between Brachiopoda and the other bivalve shells. Indeed, anatomical investigations of these animals have shown that they are not only constructed upon the same plan, but that the differences between Brachiopoda and ordinary Acephala, are scarcely as great as the differences which exist between Ascidia and Lamellibranchiate Acephala, which Cuvier nevertheless placed in one and the same class. We shall therefore consider Tunicata, Brachiopoda and Diphyra, as one great natural class under the name of Acephala, to which we also refer, as mentioned above, the type of Bryozoa, which has been so long combined with Polypi. As to Pteropoda and Gasteropoda, though they are still generally considered as two classes, we shall, for reasons explained elsewhere,* and from embryological evidence, place Pteropoda below Gasteropoda proper, not as an intermediate type between Gasteropoda and Cephalopoda; for, Pteropoda are rather an embryonic type exemplifying, in a permanent form, that stage of development of common Gasteropoda, when they are provided with large vibracula, and a thin symmetrical shell deciduous in so many of them; bearing to that state of development of the common Gasteropoda the same relation which Foraminifera bear to a still earlier period of their embryonic growth, when the yolk is undergoing its process of gradual successive division, which seems to me to be exemplified in a permanent form in the numerous cells into which the body of Polythalamia or Foraminifera is naturally divided. If this view be correct, the class of Gasteropoda would therefore consist of the three types of Foraminifera, Pteropoda and true Gasteropoda, among which we would place the Heteropoda, lowest, and the Pulmonata highest, both on account of their structure, and on the ground of the peculiar mode of development of Pulmonata.

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* See a paper upon the homologies of Gasteropoda and Acephala with reference to the systematic position of Pteropoda, Foraminifera, Brachiopoda and Bryozoa, read before the American Association, &c.

The third class is that of Cephalopoda, which has always been circumscribed within natural limits, since Foraminifera have been removed from it. The position which I ascribe here to Foraminifera will appear very natural to those who are equally conversant with the succession of fossil types in geological periods, and with embryology, and who know, as we have seen it to be the case also among Radiata, that the higher classes reproduce in their lower forms, types analogous to the lower ones. For the great number of fossil chambered shells, existing in earlier geological periods, is very striking when we compare those old representatives of the class of Cephalopoda with their condition in the present period of the creation, and the natural gradation and analogy between Bryozoa as the lowest type of Acephala, with the Foraminifera as the lowest type of Gasteropoda, and the chambered shells of old ages as lower types of Cephalopoda will remind us of similar relations between Polypi as the lowest type of the animal kingdom, the so-called Hydroid Polypi as the lowest type of Acalephæ, and Crinoids as the lowest type of Echinoderms, which are strictly parallel cases in two of the great types of the animal kingdom.

If we now start from these modifications in the classification of Mollusca which rest entirely upon anatomical and embryological considerations, to appreciate the relations between the three classes of this type, and the media in which they naturally live, we cannot fail to be struck with the circumstance, that all Acephala, with one single exception, are aquatic, as are also Cephalopoda; and that we have only terrestrial representatives among Gasteropoda. Next it must be obvious, that among Acephala we have fewer fresh water representatives, than among Gasteropoda, as the fresh water types of Acephala belong truly to two groups one of which has very few fresh water families, whilst among Gasteropoda we have quite a variety of fluviatile and terrestrial types.

The first thing which must strike us in this type, when contrasting it with the Radiata, is the circumstance of a far larger proportion of fresh water forms and of the introduction of a number of terrestrial ones. This simple fact in itself would go to sustain the hint thrown out above, that a higher organization in the animal kingdom is better adapted to the fluviatile and terrestrial life, than a lower structure; as among Radiata we have not one single terrestrial type, and only a single fluviatile one; whilst the Mollusca, the structure of which is formed upon a plan decidedly higher than that of Radiata, present already a large increase of fluviatile types, with the addition of very many terrestrial ones. But this view will at once be sustained to a most unexpected extent if we consider which of the Mollusca are aquatic, and marine, which are fluviatile, and which are terrestrial. Beginning with the Acephala, we have then, in the first place, all the

Polyp-like Bryozoa; and Tunicata, and the compound Tunicata, entirely marine, with the exception of a few genera of fresh water Bryozoa. And it is very interesting to notice that fresh water animals among Mollusca are of the lowest type of their class, as also was the first and only fresh-water Radiate,—showing thus that the types to which they belong are not adapted to rise into any of their higher developments into the forms best fitted for other elements.

Next we notice the Brachiopoda which are all, without exception, marine. Next Lamellibranchiata, mostly marine, though some of their types are fluviatile. So the entire class of Acephala is aquatic and chiefly marine, and its fluviatile types belong to its lowest group, and to its highest. This circumstance has raised the question with me, what is the proper position to assign to the Naiades among the Lamellibranchiata, and upon due consideration of their peculiar characters, and especially of the circumstance that their mantle is entirely open, that they have no prolonged syphons whilst there are such even among Ascidia, I am inclined to suppose that they rank highest among Lamellibranchiata and that Monomyarians should rank between Brachiopoda and Dimyarians. The reason for assigning to Naiades this higher rank rests upon the homology traced between the foot of Gasteropoda and that of Acephala, and between the reduction of the mantle upon the sides of the foot which it no longer encloses in Gasteropoda, and also the higher position of the gills under the margins of the mantle, all peculiarities in which Naiades bear closer resemblance to common Gasteropoda, than any other of the Acephala. Thus this class of Acephala, though chiefly marine, with a few representatives of its lowest types in fresh water, would reach its highest degree of development in one family, which is entirely fluviatile.

Among Gasteropoda we have again Foraminifera as the lowest type entirely and without exception marine; Pteropoda, which rank next, entirely and without exception marine; Heteropoda which follow, equally marine; and among true Gasteropoda, which in their class are decidedly the highest, we find first, fluviatile and then terrestrial families. And now the question is, among these, what is the respective position of the marine families, of the fluviatile families, and of the terrestrial families. There are among them such structural peculiarities as will decidedly settle the question. If we set aside for a moment the few branchiate fresh water Gasteropoda, we have a large number left which are pulmonate, and which live in fresh water and upon land, and which as a whole we may contrast with the branchiate true Gasteropoda, which are almost all marine, with the few exceptions of Valvata and Paludina and Ampullaria. Now which of these two types rank highest will not be a matter of doubt as soon as it is remembered that Phlebenterata are among branchiate Gasteropoda, and by their general structure, rank below the others. So that we shall have the marine branchiate Gasteropoda follow immediately the Heteropoda to which they are more or less closely allied through the Phlebenterata, and, above all, the Pulmonata. But here arises a new question. This family of Gasteropoda is partly fluviatile and partly terrestrial, and we may further ask, which should rank higher? No one familiar with the forms of these animals will hesitate in answering this question. We need only compare the development of their tentacles, their forms and position, and the development of their organs of sense, to be satisfied that Helices and Limax rank above Planorbis and Limnæa. So that the natural gradation established by their structure among the upper groups in the class of Gasteropoda, agrees with their natural connection with the elements in which they live in the order which I have assigned to these, the types of Gasteropoda which are lowest being exclusively marine; the highest, equally fluviatile and terrestrial; and among these the fluviatile ranking immediately above the marine, and the terrestrial ranking highest, and the proportion of the fluviatile in the whole class being still larger than in the class of Acephala, inasmuch as the structure of Gasteropoda is also a higher degree of development of Mollusca than that of Acephala, and the first terrestrial type in the animal kingdom in the gradation of its structure making its appearance in the class of Gasteropoda.

The Cephalopoda are highest among Mollusca as a class. They rank so high as to rival in the complication and development of their structure even some of the Vertebrata, and strange to say, we have among them only marine types, not a single fluviatile representative, nor a single terrestrial one. This fact would at first seem to be in direct contradiction with the statements made before, if it were not for the circumstance that this class in itself as represented in our days does not seem altogether reduced in comparison with the other two, if we could not be satisfied that its perfect period of development were the former geological ages when its numbers were far greater than at present, a circumstance which places the whole class in peculiar relations to its type, which must be rather appreciated under the point of view of the conditions which prevailed in former ages, when the ocean covered more extensively the whole surface of the globe than at present; so that the type with its high organization must be considered more with reference to its development in former ages, than to what it is now, as at present the class is proportionally reduced, and it is well known, and it will be further mentioned with reference to other types, that in earlier periods however high animals might have ranked by their structure, they were all marine, as we know fishes to have been the only representatives of Vertebrata in earlier periods.

At this stage of the investigation, a comparison between Mollusca and Radiata shows that, though the former advance farther in their fluviatile development, and even reach with some few of their types a terrestrial mode of existence, there is not yet a single family among them which is entirely terrestrial, nor a single class which is either entirely fluviatile or terrestrial, this connection with the higher conditions of existence being only introduced among some few of their representatives, which we are allowed from other data to consider as the highest in their respective groups.

If we now pass to the great group of Articulata and begin as before by revising their zoological arrangements as based upon anatomical and embryonic data, we shall have at the outset to settle the limits of their classes, and their relative positions.

The first point which we have here to investigate is the question whether Articulata in the widest extension of this group constitute one single natural type, or whether they should be subdivided into two equivalent groups, as has been proposed by those who would restore the division of worms, in its widest sense, as a great division equal in zoological importance to the type of Mollusca, and unite the Arthropoda, Crustacea, and Insects to form another group of equal value.

The great diversity among worms, seems at first to warrant in some degree, such an arrangement. But as soon as we consider the metamorphosis which insects undergo, and compare their earliest stages of growth with the structure and forms of worms, we cannot fail to perceive, that notwithstanding the many peculiarities which characterize worms, they are, after all, only one of the permanent modifications of the same type as Crustacea and insects, among which last the characters and forms of a large number of worms are reproduced as transient states of growth; so that upon the most natural view, and especially if we allow embryology to have its due weight in fixing our opinion, we must consider worms with all their diversified forms, Crustacea in all their diversity, and Lepades, Arachnidæ and Insects, to constitute one single undivided natural type in the animal kingdom. Assuming upon the foundation alluded to, and without entering into a detailed argument upon this question, that this is the right view of this subject, the next question is about the number of classes into which these Articulata should be subdivided. Taking here again anatomical and embryological evidence as our guide, and remembering what was said above of intestinal worms we shall find that the most natural combination of the different groups of Articulata will bring them all into three classes, one containing those in which the body is either more or less distinctly articulated, or in which indications of transverse wrinkles in the skin are scarcely marked, or wholly wanting, but in which, however developed these joints may be, they never combine in such a manner as to divide the body into distinct ridges, in which the form is always elongated and vermiform, never provided with articulated rings, however numerous and diversified the locomotive appendages may be, and in which the foremost joints hardly ever assume a peculiar structure with the appearance of a head. This class for which the name of Worms is best retained, will contain the Helminths and Annelides exclusive however of the vermiform parasitic Crustacea, which embryology has taught us to refer unhesitatingly, to the class of Crustacea. The extraordinary diversity which exists among these animals renders it rather difficult to subdivide them into natural groups, and to assign to these groups a natural succession agreeing with the gradation of their structure, as there are so many the development of which is as yet very imperfectly known, and others which undergo so complicated metamorphoses as to leave great doubt respecting their natural relations to each other. However, there can be no doubt that Helminths rank lower than Annelides, for their structure indicates plainly their inferiority, and their mode of existence within other animals shows that they do not even reach that degree of independence which might allow them a free existence.

Among Annelides again there will arise similar difficulties respecting the relative position of the branchiate types of that group which are provided with external appendages performing simultaneously the functions of respiratory and locomotive organs, and those families which are deprived of external appendages, or which have stiff bristles upon their joints, independent of their aërial respiratory organs. Indeed at present the position of earth worms and leeches among Annelides, has not been the subject of any direct investigation as regards their relative position and rank. But if I were allowed to be guided by the impressions I have received from the study and comparison of the larvæ of insects, I should be inclined to consider the annelides with external gills as inferior to those which have no such appendages, and place the lumbricine Annelides highest in the class. So that Helminths should be placed lowest in the class of worms; next the Branchiate Annelides with external branchiæ; next those having internal branchiæ, and highest those with aërial respiratory sacks.

The second class in the type of Articulata is that of Crustacea, the natural circumscription of which can hardly be in any degree a matter of doubt, for these animals, with their distinct articulations, and aquatic mode of respiration, external appendages and particular mode of combination of the rings of their body, wherever they are combined to subdivide the body into distinct regions, are so peculiar as to determine well the natural limits of this class, to which we refer also the Cirripeda notwithstanding their transformations, also the Lernæan parasites, though they may assume in their parasitic mode of existence so extravagant forms, and an appearance so entirely different from that of common crustacea. In this class, again, the parasitic vermiform types rank lowest; next follow the Entomostraca, and highest the Malacostraca, in most of which the anterior rings are combined into a distinct region, assuming a peculiar appearance differing widely from the posterior free movable rings. The circumstance that among Crustacea the organization reaches a point where the anterior part of the body assumes so peculiar an appearance, leaves no doubt as to the relative position of Crustacea among Articulata; they rank higher than worms; though they must be placed below the insects notwithstanding their perfect circulation and their otherwise highly developed structure; for, in every respect, insects considered as a whole class, are more highly organized, their higher types assuming a division of the body into three distinct regions; —undergoing also far more extensive metamorphosis, and assuming finally an aërial mode of respiration, to which the Crustacea do not reach. For these reasons, which I have illustrated more fully on another occasion, I have no hesitation in placing the class of insects highest among Articulata, and in comprising in one class the true insects with Arachnida and Myriopoda, which are only lower degrees of development of the more special types of true insects; the Myriopoda representing in a permanent state of development, and with the structure of true insects, the form of their caterpillars; the spiders with their cephalic and thoracic rings united into a cephalo-thorax representing their chrysalis in a permanent state of development; and the true insects with their three distinct regions, the so-called head, thorax and abdomen, ranking highest among them, as well for their more extensive metamorphosis as for the characteristic division of the body, the reduction of their locomotive appendages to a peculiar region, the complication of their chewing apparatus, and the development of their wings. The true arrangement of the different members of this class however is readily indicated by the remarks already made upon this class, and we shall not hesitate to consider Myriopoda as their lowest type, and to place Arachnida next above them, and then true Insects, among which the sucking tribes rank highest.

If we now consider the connection of these three classes with the elements in which they are developed, and in which they permanently live, we cannot fail to be struck with the fact that two of their classes are either parasites or entirely aquatic, for even the terrestrial worms live in moist ground or on the bark where moisture is constantly accumulating; and these two classes we have seen to be the lowest of the type, while the class of insects, which, in their perfect development, are all terrestrial or aërial, constitute the highest type.

Reviewing the secondary groups of all these classes also in the same connection, we find that the lowest of all not only live in a fluid medium, but require the existence of other animals in whose cavities they find shelter and means of subsistence; and among those which have an independent mode of life we find that the marine worms are probably lower than the fluviatile, and terrestrial,—at least, if the view expressed above respecting the relative position of Lumbrici and branchiate Annelides be correct.

In the class of Crustacea we have exclusively aquatic animals, and we find that among them those which live as parasites upon other animals rank lowest. The distinction however between fluviatile and marine types in this class does not seem to be in strict accordance with their gradation, for we have fluviatile Decapods which cannot be considered as higher than the crabs, unless it were shown that the shortened body of the Brachyural Decapods is the result of a retrograde metamorphosis, which I am however not inclined to suppose, as we have some crabs which are in the habit of leaving the water to dwell upon the main land. The occurrence of parasitic Crustacea upon freshwater fishes, again, seems to indicate that here the parasitism prevails over the influence of the surrounding media; and we should not wonder at this circumstance, as a parasitic mode of development dependent upon the prior existence of organized beings, is not only a prominent feature in the mode of existence of so many Worms and Crustacea, but also even of many of the Insects, especially of the tribe of Arachnida and Diptera, at least in some earlier periods of their existence. In this connection it is an interesting fact to notice that the American fresh water Crustacea, the craw fishes, have fewer pairs of gills than the other representatives of the class.

Again, it may be, that to appreciate truly natural relations of this type of animals, it will be necessary to consider separately each of their minor divisions rather than the whole class as a unit; as we shall have to do also among the reptiles where the peculiarities of the primary divisions overrule the influence of the media in which they are developed.

However obscure these relations may be among Crustacea owing to the parasitism of some of their types, or the peculiar metamorphosis of others, if we now consider the insects proper we shall find here again a strict accordance with the results we have already derived from the investigation of the lower classes. Having acknowledged the superiority of the sucking insects over the chewing tribes, we cannot fail to perceive that Neuroptera, which must be considered as the lowest, inasmuch as their body still preserves the elongated form of worms, are aquatic in their larval condition and have even external gills, as their respiratory organs during that period. Next, Coleoptera among which also we find aquatic larvæ, and a number of terrestrial types, and highest the Orthoptera which undergo a less extensive, but entirely terrestrial, development, whilst Hymenoptera have a more diversified metamorphosis, and assume even in their larval condition in some of their types, the higher forms which characterize the larves of Lepidoptera.

Among the sucking insects we begin again with various aquatic types, or aquatic larval forms,—next rise to Diptera with other aquatic larval conditions but a constant aërial mode of life in the perfect state, and finally to the type Lepidoptera in which all larvæ are terrestrial, and even highly organized in their earliest state in the higher groups; so that the class as a whole does not only rank above Crustacea for its structure, but consists chiefly of aërial types in their perfect state of development, a large number of which are aquatic but fluviatile in their larval condition, and comparatively exceedingly few marine. So that if we compare the whole type of Articulata, with either Mollusca or Radiata, we see that in accordance with the higher development of its structure it has not only proportionally a larger number of terrestrial and aërial types, but an entire class is throughout aërial in its perfect state of development, and, though aquatic in the stages of growth, these larvæ are chiefly fluviatile and not marine, so that we may conclude from zoological evidence that the more intimate connection with the main land and aërial mode of existence indicate a higher degree of development than an aquatic mode of life; and between the animals living in water, that fluviatile types must rank higher than the marine.

These views are fully sustained by the order of succession of these great types of the animal kingdom throughout the earlier geological periods; for as it is already ascertained from zoological comparisons, that the earlier types in each class rank lower than their present living representatives, we have further evidence from the circumstances under which they live that they were all aquatic and marine in the earliest periods, and that fluviatile and terrestrial types have followed only at later periods. Without alluding to those classes in which the gradation of fossil types is less distinctly shown, let me only recall the Crinoids among Echinoderms, which for so long time prevailed to the almost entire exclusion of all other families among Acephala; the great prevalence of Brachiopoda in the oldest deposits and the first appearance of Naiades in tertiary beds; the large number of branchiate Gasteropoda up to the time of the tertiary period, when Limnææ and Helices made their first appearance; the earlier development of Crustacea with more uniform joints, and the appearance of insects of the tribe of Scorpions anterior to that of the winged families, among which the Neuroptera seem to be the first to increase in number, and the late occurrence of the sucking tribes in tertiary beds, and there will be no doubt left that the gradation of structure is intimately connected with the extension of continental lands, and that the present connection of animals with the surrounding media in which they live agrees also with their natural gradation. If we would study the natural relations between animals and the media in which they live, we could not begin with better prospect of success than by investigating minutely the different families of Vertebrata separately, rather than the whole classes of this great type. For though it is at once apparent that the class of Fishes as a whole is entirely aquatic, and stands at the same time lowest among Vertebrata, as soon as we pass to the investigation of the Reptiles we find aquatic and even marine types among Turtles, which rank much higher than the whole order of Batrachians, which are almost entirely fluviatile; and we find again marine and fluviatile types among Birds and Mammalia, the highest of all Vertebrata. These facts show most conclusively that an organization as high as that of the Vertebrata —introducing a mode of existence so independent of the changes of the seasons throughout the year, so durable as to last for numbers of years, (whilst among Invertebrata, and especially among Insects, but also among many other animals of lower type, there exists the most intimate connection between their development and the course of the seasons); we say these facts show that with such animals which are placed so far above the influence of physical conditions, their connection with the circumstances under which they live is much weaker, so much so that internal structure overrules greatly the foundation of those connections which are so intimate in lower animals, and reduces their limits to subordinate connections between members of the minor groups; while in the class of Fishes—the lowest—the whole type is organized in such a manner as to make it uniformly dependent upon one of the natural elements in which animals live, the three other classes present most diversified combinations, there being marine, fluviatile, and terrestrial or aërial types in these classes, under the development of as many structural types, differing almost in the same degree when contrasted with each other and so much that the aquatic Mammalia even in their marine types, or the marine Turtles, differ as much from each other or from Birds as they agree with their respective fresh water or terrestrial types. These discrepancies between the great types may be owing to other motives in the plan of creation than those to which they are here ascribed. The apparent anomalies between some of the articulated types may also be the results of combinations different from those with which they are connected above. But whether these views are correct or not, I have no doubt that the study of the phenomena which I am now contrasting, cannot fail to lead finally to a more correct appreciation of the natural relations which exist between animals and the media in which they live, than the vague views which have prevailed lately from want of investigation of the subject rather than from an especial view taken of it; I am far from supposing that in every instance I have hit at the outset the true view. I shall be satisfied to have called forth direct investigation upon this question, and led the way in a field which promises so ample reward.

Before entering into a special investigation of the natural relations of Vertebrata and the surrounding media, it may not be out of place to call attention to some collateral facts which will appear particularly prominent in the type of Vertebrata, but which have already their value in the study of the lower types. I allude to the relative bulk of animals of the same type living in different media. We can derive no impression upon this point from the investigation of Radiata, as they are all aquatic, and almost entirely marine. But the difference is already marked between Mollusca if we contrast their marine and their fluviatile and terrestrial types within the limits of their natural secondary groups. Among Acephala, if we consider the Lamellibranchiata, we can not fail to observe that the marine representatives are as a whole and taking into consideration the proportional number of their genera and species, of larger size and greater weight than the fluviatile. We have nowhere such gigantic, bulky and heavy fresh water Bivalves, as are many of the marine shells, and we need only compare the large Chamas or Tridacnas and Hippopus, the gigantic Pinna, even with the largest of Anadonts; and again the numerous species of Cyclas, &c., with the smaller marine Bivalves, among which we find but few species of so minute types. Again, among Gasteropoda how much larger are most of the Univalve marine shells, such as Dolium, Strombus, Voluta, and others, than even the largest fresh water Ampullariæ and the whole lot of fresh water and terrestrial Pulmonata, among which latter we have absolutely the smallest of all Mollusca in the innumerable varieties of Pupa, and other genera. We reckon in this type of Gasteropoda, the minute species by hundreds, while there are exceedingly few of really small size among the marine ones, and the greater number are even universally above the medium size of the larger fluviatile and terrestrial types.

Among Articulata the same rule obtains, and here we may compare classes with classes, even in their different stages of growth. Are not the Worms, taken as a whole, larger animals than the Caterpillars? Do we not find among marine Worms by far the largest types? We need only remember the gigantic Eunice, or even the parasitic Tape Worms to be satisfied of the fact. Are not the Crustacea as a class composed of types exceeding far the largest of Insects even with their wings spread? Are not the marine Lobsters many times larger than the fresh water Craw

Fishes? A minute investigation of the details of this numerous class might lead to very interesting comparisons which however would be out of the way in this general sketch.

I shall mention only a few facts to show that these comparisons might even be traced between the different stages of growth of these animals. It must be, for instance, a matter of surprise to see that the body of so many Insects is smaller in their perfect state of development than as a pupa; and that again this is smaller than that of the larva, though the larva be after all only the younger state of the pupa, and the pupa the younger state of the perfect Insect. But in the same ratio as we find so frequently throughout the animal kingdom that the lower condition of structure and development of a type is manifested in a more bulky body, so we find among Insects, that their earlier state of metamorphosis which is developed under inferior circumstances, reaches its final growth in a more bulky body than that of following periods during which their successive moultings and the transformations of the substance of the body takes place; the greatest size which the larva acquires is first reduced in its transition into a chrysalis, and this again is reduced in its transition into a perfect Insect,—the development of wings only leaving them seemingly of greater size when their surface is extended, though the bulk as a whole be reduced. Weighing these animals in these different states of development will satisfy the most incredulous of the reality of what is here stated, should the appearance have deceived him before. A Silk Worm when it begins to spin is much heavier than the chrysalis, and this heavier than the perfect Moth. Without directly weighing these animals, we might be satisfied about this fact if we should consider the amount of silk which is thrown out by the latter, and the amount of fluid which is discharged by the Moth even before it rids itself of its load of eggs and sperm to enjoy the last moments of its complete maturity.

If we now allude to the Vertebrata we shall find very similar facts, and perhaps in the animals to be mentioned, inducements for the discovery of curious unnoticed connections. And here again we should be cautious for reasons alluded to already above, not to take the classes as such, but rather to consider their different types separately; for the class of Fishes as a whole cannot be said to contain the largest Vertebrates, nor even to afford any support to the view that aquatic animals in general are larger than terrestrial, for we find proportionably a much greater number of large species among Mammalia than among Fishes; we find a greater number of large terrestrial Reptiles than of aquatic ones. But if we review the classes separately, and consider their secondary groups by themselves, we find that the rule holds good, but bears, at the same time, most interesting reference to the order of succession in geological times, as the respective types of any given group are the larger in the present period, whether terrestrial or aquatic, for being representatives of families which had numerous representatives in older periods. Among Fishes, we find the largest in the family of Sharks and Skates, Sturgeons and Garpikes, the first of which are exclusively marine, the second marine and fluviatile, the third entirely fluviatile; but the three types are either exclusively representatives of families largely developed in former geological periods, or so connected with extinct types as to show that this connection has influenced their development.

Among Reptiles we find the largest in the family of Turtles among their marine representatives; among the Lizard-like, in the fluviatile Crocodiles; among Batrachians, in their aquatic families.

In Birds, the aquatic families, Pelicans, Geese, Ducks, &c., bear a much larger proportion of heavy bulky forms than any terrestrial families; and if the Ostrich should at once occur as a striking exception, let us not forget that the giants of this family are known in a fossil state, exceeding far their living representatives.

Among Mammalia, we have the Whales as the largest class, and if we should be reminded of the great size of terrestrial Pachyderms, let us not forget that Pachyderms were the prominent type of Mammalia during the tertiary period. In connection with these facts it might be shown that natural families throughout the animal kingdom, are constructed within limits of size, which do not admit of great differences. A comparison of Cetaceans with Rodents, of Ruminants with Bats, of Passerine with Gallinaceous Birds, of Sharks with Herrings, of Cod-fishes with Blennoids, of Cuttle-fishes with Pteropods, of Crabs with Entomostraca, &c., might easily satisfy the most skeptical, that there are natural limits assigned to certain combinations of structure and the material bulk of the animals in which they are manifested.

After this digression let us return to our consideration of the natural connection of the secondary groups of Vertebrata, with the elements in which they live.

Though the class of Fishes is entirely aquatic, we have among these animals a greater number of marine types, and some which are partly marine and partly fluviatile, or, at periods, marine, or, at periods, fluviatile; and others which are entirely fluviatile or almost so. And though, at present, it is not plain that fluviatile types on the whole are superior to the marine types, we should not lose sight of the circumstance that the only living Sauroids, which have so many characters by which they may be connected with the class of Reptiles, and considered as the highest among Fishes, are entirely fluviatile; both Lepidosteus and Palypterus occur only in fresh waters; some of the Lepidostei only are known to reach the mouths of rivers emptying into the sea. And though the families of Sharks and Skates are chiefly marine, numbers of them, especially of those types of Skates which have numerous fossil representatives during the tertiary period, such as Myliobatis, are known to ascend freely the rivers in tropical regions. Among Cyclostomes, the lowest type Branchiostoma is marine, Petrostoma proper being both marine and fluviatile, the higher type of Ammocœtes (for we must consider Ammocœtes as higher, inasmuch as the division of the lips indicates a tendency towards a formation of a distinet upper and lower jaw), is exclusively fluviatile. The Goniodonts which from their affinities to Sturgeons rank higher than the Siluridæ, are exclusively fluviatile, whilst there are some marine types among the latter. Among Percoids we find in fresh water a larger number of those in which the two dorsals are distinct, a character making them eminently superior to the forms with undivided fins. For the same reason we should consider the Sparoids inferior to the Percoids, their dorsals being not only generally undivided, but even covered with scales. Among the Eels, those destitute of all fins are exclusively marine, those without pectorals also exclusively marine, and we may fairly consider the fresh water Eels as the higher type of the family on this ground. If there is any natural connection, as I have attempted elsewhere to show that there is, between Scombroids and Scomberesoces, and Esoces proper, it becomes plain at once that the latter are the higher from the abdominal position of their ventrals, and they are a fluviatile family. Even taking the Cycloids as a whole, we find among them the lower families of Thoracici and Jugulares, as the families of Cod and Scombrides, chiefly marine, whilst the family of Salmonidæ, and Cyprinidæ are chiefly fluviatile. Among the Gadoids we have those with many vertical fins, as the true Cod, marine, while those in which the dorsals and anals are reduced such as the genus Lota are fluviatile. Even among the Salmonidæ in the widest extension which this family had formerly, we find the Scopelidæ with the inferior structure of their jaws chiefly marine, while the Coracini and true Salmonidæ are chiefly fluviatile. Everywhere, in fact, in each minor group, the fluviatile representatives show characters indicating their superiority over their marine representatives. Whatever exceptions might be found to this law, which in the outset appears so general, I have no doubt will lead at some future time to the discovery of some other principle as yet unknown.

The class of Reptiles is one of the most interesting in the point of view under consideration, and each of their types exemplifies in itself the law of the intimate connection between animal types and the media in which they live in the most striking manner, inasmuch as here the gradation, which might be inferred from structural and embryological evidence, agrees most fully with the gradation of the elements in which they live. Among Batrachians we have chiefly fluviatile and terrestrial families. The Ichthyodes, or Batrachians with permanent branchiæ, are all aquatic, and acknowledged the lowest in the class. Some of their lowest representatives occur even in brackish swamps, and, as soon as attention is called to this subject, it cannot fail to be perceived that the Frogs with their more or less palmate fingers, and their more aquatic habits, rank lower than the Toads with their divided fingers and terrestrial mode of life. Among Ophidians we have chiefly terrestrial families, and only a few marine and aquatic ones; but who can fail to perceive that the marine serpents with their flattened tail, are inferior to the terrestrial genera, and that among these it is a well known fact there are some with rudimentary posterior extremities which assigns them a superior rank. Some objections might be drawn from the consideration of the Saurians, among which, the highest type, the Crocodiles, are chiefly fluviatile; but it has elsewhere been shown that Crocodiles are not truly Saurians of the same type with our Lizards, but modern representatives of a large family which was very numerous in former geological periods, when their first representatives were marine types provided with fins instead of distinct fingers; so that, far from being an exception, the Crocodiles of our days which are either fluviatile or terrestrial, must be considered as the highest representatives of that almost extinct type of Reptiles, the earliest forms of which were marine, followed by fresh water. Finally, among Chelonians the gradation in connection with the natural elements in which they live is most striking, for the inferiority of marine Turtles is as plain as it can be, not only in the form of their organs of locomotion, but even in the peculiarity of many of their internal organs especially of their ovaries, which contain eggs almost as numerous as those of Fishes. Next we place the fresh water Turtles with palmate fingers, and highest, terrestrial Testudines with their short undivided fingers. So that we have in this class with its various marine and fresh water and terrestrial types, not only a full illustration of these laws, but so intimate a connection between gradation of structure and mode of living in various elements, as to lead to the conviction that the mere mode of living might in many instances be almost as safe a guide to ascertain the natural gradation of types, as the study of their internal structure.

Ever since the class of Birds has been the object of regular investigation, their aquatic types have been considered as inferior to the terrestrial ones, and among the former, those which live entirely an aquatic life are decidedly the lowest. They are so, not only on account of the more imperfect development of their legs, which preserve throughout their embryonic form, but also in the less extensive development of their wings, in the more scale-like form of their feathers, and the greater number of eggs they lay, and the less care they take of their young, which are hatched in a state of development in which they are already prepared to provide for their own food. The same is the case with the Gallinaceous and the Wading Birds, which, though more advanced in many respects, are still inferior to the climbing and Passerine Birds in this respect, having a heavier flight, if they fly at all, and living a more terrestrial, and even aquatic life; the Wading Birds coming nearer in this respect, to those with palmate fingers, and the Gallinaceous Birds, as well as the Ostriches having a more terrestrial mode of life, whilst the Passerine Birds rank higher in all these respects, feed their young, and take care of them for a longer time, and live almost exclusively an aërial life, few of them having aquatic habits, and those being in their respective families by their form as well as by their mode of life, decidedly inferior to their loftier relations.

The classification of Birds as a whole is still so imperfect, though their minor groups are well understood, that many important relations in these respects must necessarily be more or less concealed as long as their primary divisions are not better known; so that we may expect many interesting hints from further investigations in this view.

The class of Mammalia is not only the most diversified in the forms of its members, but also in the diversity of their mode of life; nevertheless this diversity is connected by the most intimate relations of structure. The Whales are as much Mammalian by their internal organization as the most exclusively terrestrial quadrupeds. True Cetaceans constitute a natural family, all the members of which are exclusively marine, and no one of them even fluviatile—for the Sirenidæ must be considered as entirely distinct from true Cetaceans; and these Cetaceans, at the same time that they are so exclusively marine, are also the lowest type of Mammalia, not only from the imperfection of their extremities, of which there is only one anterior pair, and from the want of hind-legs, but also from the extraordinary development and bulk of their muscular tail, and the development of a caudal fin, and sometimes even a fin-like fold of the skin upon the back. If it can be shown that the Sirenidæ are an aquatic type of a larger group embracing Pachyderms, the direct relation of their structure and mode of life will be at once obvious, since Sirenidæ are either marine or fluviatile, while true Pachyderms are terrestrial; and should we not be justified in considering the subaquatic Hippopotamus as inferior to its more terrestrial relatives of the genera Rhinoceros, Elephant, and Horse? Are we not to consider the Ornithorhynchus, with its palmate hind-legs and spur, as inferior to Echidna? Are not the palmate Rodentia inferior to the terrestrial and arboreal types? Are not the aquatic Shrews inferior to the arboreal Insectivora? All these secondary questions will receive, in future, due attention and will no doubt be satisfactorily settled. But there are families in which we can already see our way and arrive at precise conclusions. Among Carnivorous Mammalia we have three very distinct types, the Pinnipoda or Seals; the Plantigrada or Bears, and the Digitigrada, Dogs and Cats. Now even if objections were raised against the association of the Walrus with the common Seals, there can be no doubt of the inferiority of the latter when contrasted with Plantigrada and Digitigrada. Their short fin-like legs, their clumsy body in connection with their aquatic marine life, assign them a lower position, and the Plantigrada must be considered as intermediate between them and the Digitigrada. Now among Digitigrades, even if we take isolated genera, we are led to assign to the species with aquatic habits, an inferior position among their nearest relatives. The polar Bear comes decidedly nearer the Seals in all its habits, than any other species of that genus, and on that ground should be considered as inferior to the terrestrial species. Again, the others, with their palmate fingers, rank lower than their terrestrial relatives: and we may even find that such considerations will hold good among the varieties of one and the same species; for we have varieties among the Digitigrade Dogs in which the fingers are palmate, a character which is derived from the imperfect development of their legs, preserving throughout life their embryonic form; and these varieties among Dogs are the most playful and at the same time, most aquatic in their habits, preserving in their adult state characters of the young and habits of the lower types,—this playful disposition being universal even among the most ferocious of the Cat tribe. I shall abstain purposely from tracing these comparisons higher up among Monkeys, and in the human families, from fear of alluding to exciting topics; but leave it to the philosophic observer to consider how far the idea of an aquatic Monkey is compatible with the high position which these animals hold in the class of Mammalia; and how curious it is that in the human family there are races which differ so much in their natural dispositions, mode of life, habits and adaptation to higher civilization; and how closely these natural dispositions are connected with apparently insignificant peculiarities of structure.

Upon reviewing the facts mentioned above, and the inferences derived from the facts, no impartial observer can in future deny the importance of the study of the natural relations between animals and the media in which they live; and the close connection which exists between them and the gradation of their structure. But this being the case, it must be a matter of surprise that the views so long entertained of the importance of this connection, which led earlier naturalists, generally, to the classification of animals according to the media in which they live, should have been so completely abandoned, and even considered of no value at all in systematic classification. For my own part I have no doubt that this negative result has arisen from the circumstance that all aquatic animals were brought together, in these earlier attempts, without reference to their structure or organic development, while we have found that structure is the ruling principle, and that natural connection with the element, is the secondary motive by which these connections are influenced. Indeed, aquatic animals, though agreeing in many respects, and though provided with analogous apparatus to perform the same functions, have, in different types of the animal kingdom, a very different plan of structure, and very different organs to perform the same functions. I shall not enter into a detailed illustration of these differences, as I have alluded to these facts in other papers, but only recall here, the great difference which exists in these connections between the different types.

Among Radiata, which are all aquatic, we find even that the adaptation to the liquid element is introduced in a plan of structure which is widely different from the plan of structure prevailing in Mollusca, though they also are chiefly aquatic; and that even the terrestrial types of Mollusca present, for adaptation to an aërial mode of life, only a modification of their aquatic types. The same may be said of Insects, in which the structure is mainly that of the Crustacea and Worms, which are permanently aquatic types, presenting simply a transformation of those peculiarities of structure which enable the lower classes to live under water, such as will enable them to rise in their adult state into an aërial condition of existence. Among Vertebrata the case is very different. The type is constructed for a terrestrial and aërial mode of life; even their aquatic representatives have rudiments of the apparatus, which acquire the highest development in the complete terrestrial types, and most of their aquatic types are truly aërial animals living in water, just as Insects are aquatic types adapted to the air. Let us only contrast in this respect, Cetacea with common Articulata. They have a pulmonary mode of life as much as man; they have the same mode of reproduction; only their form enables them to dive under water and to dwell permanently in the Sea; but, for all their structure, they are truly aërial animals. And this is equally the case with Birds and Reptiles; and with the Fishes I am prepared to show that there is no difference in this respect. For, though in their perfect state, Fishes are exclusively aquatic, they are completely built upon the same plan with those aërial classes of Vertebrata. The difference here is only this that the branchial apparatus, which exists simultaneously in Reptiles, Birds, and Mammalia, in their imperfect condition, is developed to be a permanent organ of respiration, while it is reduced and disappears in the higher classes in proportion as the lungs acquire a greater development. In Fishes, on the contrary, the homologue of the lung remains functionally and organically in a rudimentary state, as an air bladder. But all classes have both apparatuses in an inverse state of development, and thus Fishes are as fully constructed on the plan of the higher Vertebrata as the aërial Invertebrata are on the plan of their aquatic types. But the circumstances that Fishes have the double type of respiratory organs, and that the pulmonary one which by no means exists in any Invertebrates as I have shown elsewhere, but throughout the Vertebrata including Fishes, show that the whole type of the Fishes, have to be viewed in the same light as Reptiles, Birds and Mammalia, and must therefore be only considered as a lower condition of these aërial types, and not the latter as a higher degree of the former. For tracheæ of Insects, and lungs of Spiders, are only modified branchiæ of the type of Articulata, just as much as lungs of Pulmonata are modified branchiæ of the type of Mollusca, while gills and lungs in Vertebrata are parallel systems both coëxisting in all of them and only acquiring respectively a different degree of development in each of their classes. These facts which I have traced in other papers through a special comparison of all the homologies of the different types of respiratory organs in Vertebrata, Articulata, Mollusca, and Radiata, show plainly, that the aquatic, marine, or fluviatile, and terrestrial mode of life are introduced throughout the animal kingdom by special adaptations of peculiar different systems of organs performing analogous functions; and that the failure of introducing the consideration of the adaptation of animals to the media in which they live, in the plan of their classification, must be ascribed to the fact that these analogous structures were in the beginning considered as identical features in the organization. But taking in future into consideration all these peculiarities, we shall rapidly proceed towards the full understanding of all the relations between the gradation of animals, and the media in which they live, as far as they are not yet fully understood.

An extensive review of the Vertebrata might long ago have led to such conclusions, but before they could be considered as a general law ruling the whole animal kingdom, it was necessary that they should be treated in a special manner through the innumerable types of Invertebrated animals; and we have seen that this agreement is as close and as complete throughout the types of Radiata, Mollusca and Articulata, as it is plain among Vertebrata, and the slight difficulties to which we have alluded, must probably be referred to the present state of our knowledge respecting some of them, rather than to a departure from this law in any of their types.

ART. XXXVIII.—*On a new Analogy in the Periods of Rotation of the Primary Planets, discovered by Daniel Kirkwood,* of Pottsville, Pennsylvania.

(From the Proceedings of the American Association for the Advancement of Science, 2nd meeting, held at Cambridge, 1849. p. 207.)

Mr. SEARS C. WALKER addressed the Association on the subject of a new analogy in the periods of rotation of the primary planets, discovered by Daniel Kirkwood, Esq., of Pottsville, Pennsylvania.

The subject of my present communication is contained in a letter of Mr. Daniel Kirkwood, of Pottsville, Pennsylvania, dated July 4th, of this year.

The Secretary then read Mr. Kirkwood's letter, as follows:—

Pottsville, Pa., July 4th, 1849.

SEARS C. WALKER, Esq.,

Dear Sir,—Knowing the great interest you feel in astronomical inquiries, I take the liberty of submitting the following paper to your consideration, and respectfully soliciting your opinion as to the problem which I have been attempting to solve. Is it, or is it not, deserving of further investigation? Whatever may be your decision, as I have the fullest confidence in your judgment, I shall at once aquiesce. Wishing to be as brief as possible, I will not trouble you at present with any statement of the considerations which suggested my hypothesis.

While we have, in the law of Kepler, a bond of mutual relationship between the planets, as regards their revolutions round the sun, it is remarkable that no law regulating their rotations on their axes has ever been discovered. For several years, I have had little doubt of the existence of such a law in nature, and have been engaged, as circumstances would permit, in attempting its development. I have arrived at results, which, if they do not justify me in announcing the solution of this important and interesting problem, must at least be regarded as astonishing coincidences.

Let P be the point of equal attraction between any planet and the one next interior, the two being in conjunction: P′, that between the same and the one next exterior.

Let also D = the sum of the distances of the points P, P′, from the orbit of the planet; which I shall call the diameter of the sphere of the planet's attraction;

D′ = the diameter of any other planet's sphere of attraction found in like manner;

n = the number of sidereal rotations performed by the former during one sidereal revolution round the sun;

n'=the number performed by the latter; then it will be found that $n^2 : n'^2 :: D^3 : D'^3$; or $n = n'\left(\frac{D}{D'}\right)^{\frac{3}{2}}$.

For the sake of convenient reference, I subjoin the following tables. The masses of Venus, the Earth, Mars, Jupiter, and Saturn, are taken from your edition (1845) of Sir John Herschel's Treatise on Astronomy. Those of Mercury and Uranus correspond with my hypothesis, and are nearly identical with the most recent and reliable determinations of astronomers. In other words, the mass of Mercury is very nearly a medium between the two estimates of Encke,* while that of Uranus is more than $\frac{17}{18}$ths of Struve's mass, $\frac{1}{26800}$ found by observations on the satellites.† The mean distances not being given in miles in Herschel's Treatise, I have used the table of distances in the Astronomy of Professor Norton. For Mars's period of rotation ($24^h\ 37^m\ 20^s.\ 6.$) I have adopted the recent determination of Prof. O. M. Mitchel, (*Sid. Mess.*, vol. i, p. 52).

TABLE I.

Planet's name.	Mean Distance from the Sun in miles.	Mass.	Square root of Mass.	No. rotations in one Sid. Period.	Log.
Mercury,	36,814,000	277,000	526·3	87·63	1·942653
Venus,	68,787,000	2,463,836	1569·6	230·9	2·363424
Earth,	95,103,000	2,817,409	1678·5	366·25	2·563777
Mars,	144,908,000	392,735	626·7	669·6	2·825815
Jupiter,	494,797,000	953,570,222	30879·8	10471·	4·019988
Saturn,	907,162,000	284,738,000	16874·1	24620·	4·391288
Uranus,	1,824,290,000	35,186,000	5931·5		

The points of equal attraction between the planets severally (when in conjunction) are situated as follows:—

TABLE II.

	Miles from the former.	Miles from the latter.
Between Mercury and Venus,	8,029,600	23,943,400
" Venus and Earth,	12,716,600	13,599,400
" Earth and Mars,	36,264,600	13,540,400
" Jupiter and Saturn,	266,655,000	145,710,000
" Saturn and Uranus,	678,590,000	238,538,000

It will be seen from above, that the diameter of the earth's sphere of attraction is 49,864,000 miles. Hence the diameters of the respective spheres of attraction of the other planets, according to my empirical law, will be found to be as follows:—

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* See Prof. Encke's letter to Mr. Airy, dated Dec. 20, 1841.

‡ Edinburgh Phil. Journal, for July, 1848.

	Diam. of Sphere of Attr.	Log.
Mercury, ...	19,238,000	1·283704
Venus, ...	36,660,000	1·564218
Mars, ...	74,560,000	1·872479
Jupiter, ...	466,200,000	2·668594
Saturn, ...	824,300,000	2·916127

Remarks.—The volumes of the sphere of attraction of Venus, Mars, and Saturn, in this table, correspond with those obtained from Table II; that of Mars extending sixty-one million miles beyond his orbit, or to the distance of two hundred and six million miles from the sun. This is about two or three million miles less than the mean distance of Flora, the nearest discovered asteroid. That of Mercury extends about eleven million miles within the orbit; consequently, if there be an undiscovered planet interior to Mercury, its distance from the sun, according to my hypothesis, must be less than twenty-six million miles. Jupiter's sphere of attraction extends only about two hundred million miles within its orbit, leaving eighty-nine million miles for the asteroids. It is only in the most distant portion of this space, where small bodies would be less likely to be detected, that none have yet been discovered.*

The foregoing is submitted to your inspection with much diffidence. An author, you know, can hardly be expected to form a proper estimate of his own performance. When it is considered, however, that my formula involves the distances, masses, annual revolutions, and axial rotations, of all the primary planets in the system, I must confess, I find it difficult to resist the conclusion that the law is founded in nature.

Very respectfully, your obedient servant,

DANIEL KIRKWOOD.

[The reading of Mr. Kirkwood's letter was followed by remarks by Mr. Walker who pronounced the analogy the most important which has been brought forward since the time of Kepler. Mr. Walker also read a paper prepared at the instance of Mr. Kirkwood, containing a mathematical examination of the law, in its application to the whole Solar System, using the most recent values for the elements of the planets. Another paper on the same subject was read by Prof. B. A. Gould. These we defer to our next number.]

We annex the following Letter, dated Pottsville, January 23, 1850, from Mr. Kirkwood containing a brief history of his very important discovery.—EDS.

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* It may be proper to remark that *one planet* between Mars and Jupiter, with a mass and mean distance of about double those of the former, would perfectly satisfy the conditions of my theory.

The following is a very brief history of the astronomical discovery communicated to the American Association for the Advancement of Science, at its session in Cambridge, Mass., in August, 1849, by Sears C. Walker, Esq.

My first notions in regard to the existence of an unknown law regulating the revolutions of the planets on their axes, date some time previous to the commencement of 1839. No investigation of the subject, however, was undertaken until the spring or summer of that year, when, in reading Young's Mechanics, I was struck by the remarks at the 204th page in support of the conjecture that both the progressive and rotary motions of the heavenly bodies were originally communicated by the same impulse. While reflecting upon the subject it occurred to my mind that an examination of this theory, in case it were founded in truth, might possibly develop that harmony, of which I had for some time entertained a vague conception. Having determined to give the subject my earnest attention, I commenced by calculating the distance from the centre of each planet to the point at which, according to the known laws of dynamics, the projectile force must have been impressed.* These distances I compared with each other in a great variety of ways. Failing thus, however, to detect any relationship between the different members of the system, I abandoned this hypothesis as hopeless.

After this, my leisure hours were spent for several years, with no better success, in comparing the masses, volumes, densities, distances, &c. At length, as the only remaining source of hope, I took up the nebular hypothesis of Laplace. This was in 1846. Here I soon found that a proper discussion of the questions which presented themselves required an analysis beyond my reach, and that consequently there was little prospect of attaining my object by any direct process of mathematical reasoning. Still, however, I could not persuade myself utterly to abandon my laborious though hitherto unavailing pursuit.

I had not been long engaged in my researches on the nebular hypothesis when the diameter of the sphere of attraction presented itself to my mind as a probable element of the law sought. Further consideration of the subject led to the conjecture that the ratio of the angular velocity of translation to that of rotation, or, which is the same thing, the number of a planet's days in its year, might be another element. Finally, on the 12th of August, 1848, I obtained the simple analogy announced a few months since in my letter to Mr. S. C. Walker. My delight as I applied it to the different planets in succession and found its wonderful agreement with the known elements of the system, may well be imagined.

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* In these calculations I was, of course, under the necessity of making certain assumptions in regard to the variation of density from centre to surface.

Some time previous to the date of my discovery, I learned that the nebular hypothesis had been abandoned by some of its most distinguished advocates in consequence of the revelations of Lord Rosse's telescope. This fact, together with several other considerations, prevented me from at once making the result of my investigations public. Having, however, again and again revised my calculations, and having found that according to the theory of probabilities there are many millions of chances to one against the accidental coincidence of so many independent variable quantities, I ventured to submit the subject to the inspection of astronomers. The interest it appears to have excited, and the favor with which it has been received, have exceeded my most enthusiastic anticipations. If it be indeed the expression of a physical law and not a mere harmony, it undoubtedly opens to men of science a vast field for cultivation.

ART. XXXIX.—*On the so-called Biogen Liquid;* by CHARLES GIRARD, Member of the Boston Natural History Society.

THE following pages are devoted to an examination of a letter published in the *American Journal of Science and Arts*,* also of a communication read before the *Boston Natural History Society* in December, 1848.†

The letter consisted of an exposé of three facts and one theory, viz.:

First fact. The formation of the egg in the ovary, as observed in a soft-shelled mollusk (*Ascidia*) and in a worm (*Sigalion*).

Second fact. The germinative vesicle does not always and necessarily disappear before the division of the yolk.

Third fact. There exists in the centre of the germinative spot, a transparent vesicle.

Theory. What embryologists have called albumen in the egg of invertebrated animals, has nothing in common with the albumen of the egg of Vertebrata. This liquid is the *mother liquid* of the yolk, that is to say, of the elements from which a new individual originates; therefore it is called *Biogen.*

These facts which have been added to science were not first made known by Mr. Desor. The theory is really his own. We shall presently see on what it rests.

In the communication read before the Boston Natural History Society, besides a brief account of the letter just mentioned, we find introduced some comparisons between certain pretended phenomena which are said to take place in the earlier age of the egg and the merely conjectural phenomena of the nebular hypothesis.

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* Second Series, vol. vi, No. 21, (May, 1849,) p. 395.

† See Journal of that Society, vol. iii, p. 85.

Without further prefatory remarks, I proceed directly to take up one by one the facts, the theory, and the speculations.

I. The primitive egg has been made the subject of much research by Prof. Agassiz, especially in the department of Mollusca. Ascending even beyond the first existence of the egg, he has shown us the ovary itself in the process of development. This is composed of sacks or pouches varying in form and size, in which the eggs are formed. The sacks are filled with an homogeneous and transparent liquid. Soon this liquid becomes granular, that is, consists of cells, and the cells becoming more and more numerous, give birth to a little opaque sphere, which is the vitellus. The germinative vesicle and the germinative spot have appeared during the formation of the yolk, and sometimes even prior to this period; but at the moment when the phase of division commences, both the spot and the vesicle generally disappear, and in the interior of each of the spheres produced by the division, is seen a clear space.

A Résumé of these observations has been published.* Since then, Mr. Desor has observed analogous phases in other animals. He published them, as he had a right to do, but he should have at least declared at the outset, that he was doing nothing more than repeating the observations which another had made before him.

II. When an egg has reached that point of its history which is called its maturity, it is distinguished by the following characters:—a spherical mass, more or less opaque, which is the yolk; in the center of this is found a much smaller sphere, the germinative vesicle, containing another substance, usually transparent; then in the interior of this last, a sphere or spheres still smaller, the germinative spot or spots.

The epoch of the appearance of the germinative spot varies as it would seem within very considerable limits. This is not the place to discuss this question. Let it be observed, however, that they exist in every egg when it is mature, and that they disappear from every egg when it enters upon the period of division.

But among the Nemertes a curious phenomenon is observed. Generally as we have just said, the vesicle and spot disappear before the division of the yolk, or, at least, at the moment when it divides in halves. The secondary spheres resulting from the subdivisions of the vitelline mass, have then, each one in its interior, a clear space. The question has been raised, what part the germinative vesicle plays in the history of the eggs? Is the division the consequence of its disappearance? in other words, is its content necessary to effect the division. The germinative vesicle has been considered as containing the primitive elements of the new being, or an element indispensable to its formation. Now here, among the Nemertes we meet with a case where the yolk is already divided into four parts, while the germinative vesicle still exists. The division of the yolk, then, can take place without the previous bursting of the germinative vesicle.

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* Lectures on Comparative Embryology, by Louis Agassiz. Boston. January, 1849.

This fact is set forth and illustrated fully in the Lectures on Comprehensive Embryology,* and what appears strange to us, is, that Mr. D. now takes for his own, an observation to which he strongly objected when it was first communicated to him. Having made his observations upon a species different from that in which the fact was originally observed, there was, it seems to me, sufficient merit in pointing it out in another species, without claiming for himself the absolute priority.

III. In 1840, Mr. Martin Barry and Prof. Valentin, simultaneously observed, the one in England in the egg of the Rabbit; the other upon the shores of the Mediterranean, in the egg of a sea Urchin, (*Echinus lividus*,) that the germinative spot is not so simple as had been previously supposed. The observations of Mr. Barry were published during the same year;† those of Prof. Valentin, written in 1840, did not appear till 1842, and at this time he was still unacquainted with those of the English micrographer, for he would not have failed to mention observations so curious and a coincidence so remarkable. Prof. Valentin merely says that a round opaque body is often discerned in the center of the germinative spot.‡ In 1841, Van Beneden§ observed a granule in the germinative spot of the *Hydractinia rosea*, and in 1844,‖ when reconsidering the same species, he detected an opaque corpuscle within the germinative spot. This fact I have verified in 1848, in the case of the common sea Urchin (or sea egg) of Massachusetts Bay.

More recently Mr. D. says, that he has observed in a worm (*Sigalion*), and a sea anemone (*Actinia*), that the germinative spot contains a clear transparent vesicle. Comparing then this clear vesicle with the opaque nucleus observed by Prof. Valentin, he calls it *Vesicula Valentini*.

We honor the homage rendered to Prof. Valentin:—but Mr. D. has failed to explain how it happens that a transparent vesicle in the worms and sea anemone, is the same thing with the opaque nucleus of the sea Urchins; and moreover he ought not to have overlooked two points of its history, those which belong to Mr.

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* Pages 70, 71.

† Researches in Embryology: Third Series.

‡ Anatomie du genre Echinus, p. 105, Pl. viii, fig. 167.

§ Bulletin de l'Académie de Bruxelles.

‖ Recherches sur l'embryogénie des Tubulaires.—Mém. Acad. Brux., vol. xvii, p. 62, Pl. vi, fig. 6.

Barry and Van Beneden. By examining more closely, and studying more intimately the contents of the germinative vesicle and of the germinative spot, he might have satisfied himself that the presence of a clear vesicle, or of an opaque nucleus, indicates only two states of one and the same phenomenon, since they are observed alternately in the same species. This is the case with the eggs of Ascidiæ, of Medusæ, of Echini, and probably the eggs of many others.

By merely reading the paper of Mr. Barry, he might have been convinced that this observer had seen much deeper than any of his predecessors. Mr. Barry has pointed out a cellular content in the germinative vesicle, a thing then new to science; he believes this substance to be produced by changes which take place in the germinative spot. I do not enter into more full details upon the researches of Mr. Barry, for in that case I should be obliged to make some objections of secondary importance, which is not here my object. I had only to point out a fact, to correct an oversight. I now return to my subject.

IV. The researches of Mr. D. upon the development of the eggs of Ascidiæ, have led him to imagine a theory. This theory rests upon a false fact. According to this theory, the primitive state of the egg is a little sphere containing a transparent homogeneous liquid, in the midst of which sphere, may be already seen the outline of the germinative vesicle and spot. By degrees this liquid becomes *turbid*, and the germinative vesicle appears surrounded *by a slight cloud* which increases in extent until it fills the sphere of the egg. Then finally there is a retreat of the matter from the circumference towards the centre of the egg where it is condensed and forms the yolk. A free space remains between this last and the external membrane. This space is filled by a liquid; this liquid is the Biogen.

Having examined during many weeks and continuously each day the eggs of the same Ascidia which was the subject of his observation, I have never witnessed this phenomenon. And yet I examined them in individuals of very different sizes, and in most diverse conditions, taking care always that the egg should remain in its natural state; never, I repeat it, did I see this phenomenon of gradual condensation and of the retreat of the vitellus. Having tried all the good methods of which we can avail ourselves in the use of the microscope, the idea occurred to me to compress strongly a fragment of ovary. What was my surprise, at seeing living copies of the figures published upon this subject. It could even have been easy to make a more complete series of them. The eggs were no longer in their natural state; they were pressed down or crushed, their natural state destroyed, and this was the foundation upon which was built the theory of Biogen liquid, which was to apply to the whole animal kingdom.[*]

What then is the liquid, and what part does it play in the history of the egg? This liquid is albumen, the albumen which is formed in the ovary, and to judge rightly of the part which it takes in the formation of the egg, some general considerations upon the primitive state of eggs are here necessary.

Prof. Agassiz[†] has already reminded us that the point of departure of the egg is the same as that of the cells of the organic tissues. There is a period when the ovule is only a minute cell. More recent observations confirm these first results. To know the origin of the egg, we must then ascend to the origin of cells.

There are *primordial cells*, and *derived cells*. The experiments of Dr. Ascherson,[‡] have taught us that primordial cells are formed of two substances; of an oily substance and of albumen. Cells perfectly like primordial organic cells can be made artificially by bringing an oily liquid into contact with albumen, although the albumen and the oil or oily matter show a perfect continuity of substance when we examine them separately. But bring them in contact, and cells are formed immediately. Every physiologist can repeat these experiments, and ought to do it.

Primordial cells once formed in the manner above indicated, another phenomenon presents itself. They become nucleated, and these nuclei enlarging, give birth to derived cells.

Thus derived cells are multiplied by the growth of the nuclei, according to the researches of Mr. Martin Barry,[§] of Prof. Agassiz and my own, and whenever the third generation appears, the parent cell bursts and allows its contents to escape; it is in this way that they increase in number.

Now the only difference there is between the cells of the tissues and eggs, is that in these last the parent cell never bursts,[‖] the primordial cell preserves within itself all the subsequent generations of derived cells; which by their accumulation, form the substance out of which the new individual is produced.

Applying now this knowledge in a more special manner to the development of eggs, we can reply to the question asked above, viz., what part does the albumen play?

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[*] If the Biogen is so general, I would ask why it was not shown in the Sigalion and the Sabella of which Mr. Desor also speaks?

[†] Lectures on Comparative Embryology, 1849, p. 81.

[‡] Ueber den physiologischen Nützen der Fettstoffe und über eine neue auf deren mitwirkung begründete und durch mehrere neue Thatsachen unterstützte Theorie der Zellenbildung.—In Müller's Archiv. fur Anatomie Physiologie, &c. 1840, p. 44. —Comptes Rendus de l'Institut, vol. vii, 1838, p. 837. (*Sur l'usage physiologique des corps gras.*)

[§] Researches in Embryology: Third Series.

[‖] I mean, at least, as long as the new individual is not ready to escape out of the egg.

At a determinate epoch, for each species, the ovarian sacks are filled with primordial cells. It would be premature to raise the question whether they are formed in the ovary itself, or are brought there already formed. Let us take them, as they exist in the ovary. There under the influence of the organism, they pass through that course of development which we have pointed out as proper to cells destined to become eggs. They contain at first oil. By endosmosis albumen passes through the envelop or membrane, and coming in contact with the oil, cells are formed, the constituent cells of the vitellus (the granules of the yolk). When the oil is exhausted, no more cells are formed. The mass of the vitellus then increases, after the ordinary method of multiplication by the growth of nuclei. The albumen itself continues to penetrate through the membrane of the cell, which has now become an egg. It remains under the form of albumen, and surrounds the vitelline globe with a concentric zone more or less thick which increases as the egg grows larger. The intermediate space between the yolk and the external envelop (*chorion*) being increased, one would be tempted to acknowledge a withdrawing of the vitellus from the circumference towards the centre, if it were not known that all parts of the egg enlarge in the same proportions. Besides, a yolk which retreats, which is condensed, ought to occupy a less space, while the contrary is the fact, even as shown by the drawings made by Mr. Desor himself.

The conclusion is doubtless, already anticipated, that the pretended biogen liquid is found to be nothing more than an accumulation of albumen, the albumen formed in the ovary. An embryologist would have known that the yolk of the egg of all animals is composed of albumen and of an oily substance, and that no one has ever supposed the first of these two substances to be formed in the oviduct. When the albumen deposited in the oviduct is spoken of, it is the white which surrounds the yolk of the egg of certain animals that is referred to, and it is altogether gratuitous to attribute to embryologists doubts on this subject. I think Mr. Desor is the only person who has ever confounded the albumen of the vitellus, with the albumen which *surrounds* the essential parts of the eggs common to all animals.

When mature eggs are to be referred to a uniform type, it is necessary to distinguish between the *essential* parts (the vitellus or yolk, the germinative vesicle and the germinative spot), and the *accessory and protective* parts (the external albumen or white, the shell-membrane and the shell itself). The former are identical throughout the animal kingdom, they are never wanting; they are therefore necessary. The latter are not absolutely necessary, and as a proof of this, they are modified according to circumstances, and, in an infinite number of cases, are entirely wanting.

Starting now from the structure of the egg and knowing it to be identical in its constituent elements throughout the whole animal kingdom, the doctrine of its crystallization from a *mother-liquid* refutes itself. The idea that the vitellus is precipitated, or is crystallized, is indeed very strange. Is not this the distinction which we make between the inorganic kingdom and the organic kingdom, that the former is *crystallized*, while the latter is *organized*.

And then as to the physical characters of this biogen liquid, and the method of distinguishing it from albumen, not a word is said. All that has been done is the substitution of a name, the thing newly named is hidden from the eyes of physiologists. To explain the formation of eggs in the animal kingdom, Mr. D. thus finds himself obliged to procure the intervention of a liquid of which he knows nothing,—a liquid which would make the function of the ovary of secondary importance,—a liquid which would substitute itself for the vital action of the organism, an action which physiology explains,—in fine, an occult liquid, which sound philosophy disowns.

To oppose such a liquid to the vital action of the organism in the procreation of the substance, from which new individuals arise, is to go out of the domain of science. Mr. D. moreover has found that his biogen liquid runs through various modifications. This liquid then has no permanent character, it is under the influence of something beyond it, which produces it in its turn.

Anatomy and physiology are our guides in our embryological researches;—one confirms the other. Remaining within these limits, it was not necessary to go beyond the bounds of sound philosophy, and to fancy a theory which rests upon nothing, which teaches nothing new, which explains nothing, and which stands apart, isolated from physiology.

Thus the theory of biogen, applied to the egg of Ascidia, is not even probable; applied to the animal kingdom it is absurd.

V. § 1. Prepossessed by the false notion that the vitellus is formed by condensation, Mr. D. compares the formation of eggs to that of the celestial bodies, according to the nebular hypothesis.

But in order that a comparison of one phenomenon with some other phenomenon may be established, it is necessary that the one with which the comparison is made, should be perfectly demonstrated,—it must be a law or a principle.

Now the author forgets that the question of the condensation of the heavenly bodies according to the nebular hypothesis, is one of the most controverted questions. The fact is that we know nothing positively respecting the origin of the stars. Has the matter of which they are composed, been diffused throughout space under the form of what has been called nebulæ, and has it been gradually condensed around a nucleus to acquire its sphericity under the power of universal attraction, and to assume then a given movement and a determined direction?

There is no astronomer who can answer this question in the affirmative. From the study of our globe we arrive at the idea that it has had a beginning, and that it was originally in a fluid state. Beyond this, all is conjecture. Reasoning from the earth to the stars, we acknowledge, for all, a beginning of which we are ignorant.

It is then a false generalization to compare the phenomena of ovulation with the theory of the condensation of the sidereal bodies.

But let it be for a moment granted that the stars have been formed by the condensation of matter at first diffused. Where is the analogy between what ought then to take place, and what we witness in the formation of the egg?

The point of departure of organized beings is a sphere—the sphere is the figure of the celestial bodies; this is the whole of the analogy! In that sphere which constitutes the egg, two liquids are brought in contact and having an affinity for each other, they combine and form the vitellus which, from the first, is distributed equally throughout the whole sphere, less dense, it is true, at the beginning; but never showing the least tendency to centripetal motion, the least disposition to be precipitated around the germinative vesicle. There is never any retreat of the vitellus from the periphery towards the centre; there is no gravitation; there is a molecular attraction in the interior of a sphere, there are two liquids which are associated together, and not one liquid creating another out of itself.

Thus then should the theory of the condensation of the heavenly bodies be true, that of the eggs arising from *biogen* would not even be its analogue. Where is the biogen of the stars? No astronomer has had the hardihood to imagine a mother liquid, a gas, or any substance whatever preëxisting in space to create matter, and to disappear after having undergone various modifications.

§ 2. But Mr. D. stops not here. After having found *the great law of attraction at the bottom of the formation of organic bodies*, he comes to the question of movement. "As soon," he says, "as the egg enters upon its organic life, it begins to revolve." There are, indeed, a few invertebrated animals in which the embryo is subjected to a rotatory movement within the envelop of the egg. When one witnesses this for the first time, his thoughts naturally revert to the rotatory movement of the celestial bodies. But on looking deeper into the subject, he soon perceives the difference. I have described the movements which take place in the embryo of a marine Planaria.* I have shown that there is nothing regular about them, no subjection to law. The young animal itself regulates and controls them. There are vibratory ciliæ, that is to say, organs of locomotion, and where these do not exist, vibratory cells. There is not an external force under the dominion of which it is caused to move.

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* Proc. of the Amer. Assoc. for the Adv. of Sciences, Second meeting, held at Cambridge, August, 1849. Cambridge, 1850. 8vo, p. 400.

The egg possesses organic life from the moment when it appears under any form whatever, therefore it cannot be said to acquire it when it begins to move. Besides eggs, as eggs, move not; when they move they are no longer eggs; they are *embryos*. For when movement occurs it does not take place till after the division of the yolk; and after that division, the embryo exists.

So that in this view also, the comparison is false.

Art. XL.—*Note on Heteronomic Isomorphism;* by J. D. Dana.

In the table on page 241, of this volume, the mineral Petalite is placed with the triclinic feldspars. The cleavages appear to correspond more correctly to a monoclinic form, although as far as now understood, not wholly analogous to the ordinary feldspars in direction. In the C atomic volume, as determined, it is identical with the monoclinic feldspars. The atomic volumes of the feldspars will then stand as follows:

	A.	B.	C.
I. MONOCLINIC.			
Orthoclase,	1388	231·3	60·4
Ryacolite,	867	216·7	57·8
Loxoclase,	1068	212·6	56·0
Baulite,	2178·1	217·81	55·85
Petalite,	6071·8	224·96	57·8
II. TRICLINIC.			
Albite,	1280·4	218·4	55·67
Labradorite,	795·5	198·9	53·08
Oligoclase,	1088·3	207·66	54·647
Andesine,	2912·4	208	55·0
Anorthite,	1959	195·9	52·94
Voegite,	2966·5	197	52·84

Topaz and Andalusite approximately isomorphous.—The angle of the vertical prism of Andalusite is 91° 20′, and in Topaz there is the corresponding angle 93° 7′ (form $\infty\breve{P}2$, as usually taken). In the former, $P:a$, (a brachydiagonal prism,) =144° 50′ Teschemacher, 140° Phillips, while topaz has the corresponding angle 138° 3′. Rammelsberg has recently suggested that in topaz the fluorine replaces oxygen, and that the formula is essentially $\bar{A}l^3\,\bar{S}i^2$, with one-seventh of the oxygen replaced by fluorine, or as written out in full,

$$6[3Al^2O^3+2SiO^3]+[3Al^2F^3+2SiF^3].$$

As this, excluding the fluorine, is the formula of Andalusite, the isomorphism here pointed out may be a case of ordinary isomorphism.

Manganocalcite.—This species is a trimetric carbonate of manganese, illustrating the remark on page 239.

ART. XLI.—*On some Minerals recently investigated by M. Hermann;** by JAMES D. DANA.

1. GIBBSITE.

THE analyses of Gibbsite by Hermann, according to which Gibbsite is a phosphate instead of a hydrate of alumina,* are alluded to by Prof. Silliman, Jr., in his memoir, in volume vii, of this Journal, page 411, where this chemist, by several analyses, sustains the original view with regard to this species, his results giving much less than one per cent. of phosphoric acid. Hermann in a late memoir† publishes the following as his recent conclusions upon the Richmond mineral.

	1*a*.	1*b*.	2.	3.
Phosphoric acid, . .	37·62	26·30	15·30	11·90
Alumina, ...	26·66	38·29	50·20	53·92
Water, ...	35·72	35·41	34·50	34·18

Nos. 1*a* and 1*b* were two specimens somewhat foliated on limonite; G.=2·21. No. 2 was a stalactitic mass; G.=2·44. No. 3 was porous with an earthy fracture; G.=2·20. The phosphoric acid is here made a very varying constituent.

This species, from Richmond, has recently been analyzed by Mr. Crossley in the Laboratory of Dr. C. T. Jackson, with direct reference to the occurrence of phosphoric acid (as in Prof. Silliman's investigations), and he has found that his specimens *contained no phosphoric acid, and were a true hydrate.* The mineral is therefore identical with Rose's hydrargillite and includes that species, as has been before suggested.

2. WILLEMITE, OR ANHYDROUS SILICATE OF ZINC.

The anhydrous silicate of zinc was first recognized as a species by Vanuxem and Keating, who published a full and accurate description both physical and chemical, in 1824, in the Journal of the Academy of Natural Sciences of Philadelphia, volume iv, page 8. They describe the form of the crystals, as occurring at Stirling, New Jersey, and give the angle R : R, 118°, which was offered as only an approximation, the faces being irregular and rough.

Subsequently, Dr. Thomson of Glasgow received specimens. He described the mineral physically nearly as done by Vanuxem and Keating,‡ mentioning the hexagonally prismatic form with trihedral summits, though giving the angle 124° instead of 118°, observing however that it was "impossible to measure the angles," as the planes were so very uneven. He states that the above-mentioned authors had made it out a *silicate of zinc.* His investigations transformed it into a silicate of manganese with the composition

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* Jour. für Prakt. Chem., xl, 32. † Ibid, xlvii, 1.

‡ Ann. Lyceum Nat. Hist., N. Y., iii, 1828, and Mineralogy, 1836, i, 519.

$\dddot{S}i$ 30·650 $\dot{\bar{M}}n$ 46·215 $\bar{F}e$ 15·450 moisture and carbonic acid 7·300=99·615.

Dr. Thomson's reputation at that time served to put the blunder on Vanuxem and Keating. The mineral was named Troostite, and Thomson's analysis assumed as the correct one. Recently the so-called Troostite has been examined by Hermann,* who has confirmed the original analyses, both results giving the formula $\dot{Z}n^3\dddot{S}i$ = Silica 72·47, oxyd of zinc 27·53, or the constitution of Willemite. The analyses hitherto made of the American and foreign Willemite are as follows:—

1, 2, Vanuxem and Keating (loc. cit.); 3, Hermann (loc. cit.); 4, Thomson (Min. i, 545); 5, Levy (Ann. des Mines, [4], iv, 515); 6, Rosengarten (Rammelsberg's 3d Supplement to his Handwörterbuch, 65); 7, 8, Monheim (Verh. Nat. Vereins. Rheinl., 1848, and Rammelsberg's 4th Supplement, 114); 9, 10, Delesse (Ann. des Mines, [4], x, 211).

	$\dddot{S}i$	$\dot{Z}n$	
1, Stirling,	25·44	68·06	$\bar{F}e$, $\dot{\bar{M}}n$ 6·50 = 100·00, Vanuxem and Keating.
2, "	25·00	71·33	$\bar{F}e$ 0·67, $\dot{\bar{M}}n$ 2·66 = 99·66 " "
3, "	26·80	60·07	$\dot{M}n$ 9·22, $\dot{M}g$ 2·91, $\dot{F}e$ *trace*, loss by ignition 1·0=100 Herm.
4, Moresnet,	26·97	68·77	$\bar{F}e$ 1·48, $\bar{A}l$ 0·66, ib. & trace $\dot{Z}n$, $\bar{F}e$ 0·78, $\dot{H}$ 1·25=99·91, Thom.
5, "	27·05	68·40	$\bar{F}e$ 0·75, loss by ignition 0·30 = 96·50, Levy.
6, Silesia,	27·34	70·82	$\dot{F}e$ 1·81 = 99·97, Rosengarten.
7, Stolberg,	26·90	72·91	$\bar{F}e$ 0·35 = 100·16, Monheim.
8, "	26·53	69·06	4·36, $\dot{C}a$ 0·41, $\dot{M}g$ 0·13, $\ddot{C}$ 0·04 = 100·53, Monheim.
9, "	27·28	72·37	$\dot{F}e$ 0·35 = 100, Delesse.
10, Stirling,	27·40	68·83	0·87, $\dot{M}n$ 2·90 = 100, Delesse.

Hermann gives the specific gravity of the Stirling ore 4·02; Vanuxem and Keating 3·89–4; Thomson for the Willemite 3·935, and Levy 4·16–4·18. No. 7 (from Stolberg near Aix la Chapelle) was crystallized; G. = 4·18. No. 8 massive; G. = 4·02–4·16. No. 10, the Stirling mineral, according to Delesse, has G. = 4·154.

The crystals of Troostite have besides the primary rhombohedron (115°) another truncating its terminal edges, $(-\frac{1}{2}R)$ with $R:R=142° 52'$. The crystals of Willemite are quite small, being but 2 or 3 millimeters long and 1 thick. They are hexagonal prisms, but the prism is intermediate to that of Troostite; and the trihedral summit has according to Levy the angle of 128° 30′ nearly, the planes not admitting of very accurate measurement,—corresponding possibly to the rhombohedron $\frac{4}{5}R$, which has this angle 127° 33′.

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* Jour. für prakt. Chem. of Erdmann and Marchand, xlvii, 11.

3. RHODONITE, OR MANGANESE SPAR.

Rhodonite was long since shown to be a manganese augite, and the Fowlerite of Shepard is recognized by Hermann as giving the angle of augite; M : M=87° 6′. Hermann has analyzed the Stirling, N. J., mineral with the following result,

	$\dddot{\mathrm{Si}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Zn}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	
	46·48	7·23	31·52	5·85	4·50	3·09	loss by ignition, 1·00=99·67
Oxygen,	24·13	1·60	7·06	1·15	1·28	1·22	

giving for the oxygen ratio for protoxyds and silica 12·31 : 24·13, or very nearly 1 : 2, as in the received formula $\dot{\mathrm{Mn}}^3\,\dddot{\mathrm{Si}}^2$. He obtained the specific gravity 3·63.

Hermann has also analysed the manganese spar of Cummington, Massachusetts, and has concluded that the mineral instead of being a manganese augite is a manganese hornblende, that is, has the oxygen ratio 4 : 9 and formula $\dot{\mathrm{Mn}}^4\,\dddot{\mathrm{Si}}^3$.

His analysis gave

	$\dddot{\mathrm{Si}}$	$\dot{\mathrm{Mn}}$, *trace* of $\dot{\mathrm{Fe}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$
	48·91	46·74	2·00	2·35=100·00
Oxygen,	25·38	10·37	0·57	0·91

The result affords the oxygen ratio for protoxyds and silica 11·85 : 25·38 or very closely 4 : 8½, which is as near augite as the hornblende ratio. He unites with his *mangan-amphibol*, Thomson's sesquisilicate of manganese from Stirling, which according to Thomson has the angle 123°30′, which is nearly that of hornblende. But Thomson's analysis proves the crystallographic measurement of little value, since it makes the species a *mangan-augite*—it giving

$\dddot{\mathrm{Si}}$ 42·40 $\dot{\mathrm{Mn}}$ 50·72 $\dot{\mathrm{Fe}}$ 6·76

or even less silica than required for an augite, instead of the excess which would make it a hornblende.

The mineral of Cummington often contains disseminated through it visible points or grains of silica, and if in visible grains, there will be also invisible silica, and enough to account probably for the hornblende composition. M. Adolph Schlieper, now of Lowell, Mass., has examined and analyzed the Cummington mineral, from specimens placed in his hands by the writer, and he attributes the excess of silica to this source. His analysis gives the oxygen proportion 11·36 to 26·6, or quite closely 4 : 9. He found the mineral to be partly soluble in acids and by this means separated it into an *insoluble* portion 90·15 per cent., a *soluble* 9·85.

The insoluble part afforded

	$\dddot{\mathrm{Si}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Fe}}$
	51·21	42·65	2·93	*trace*	4·34=101·13
Oxygen,	26.6	9·56	0·84		0·96

The soluble part consisted of carbonates as follows,

$\dot{\mathrm{Mn}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{Fe}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{Ca}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{Mg}}\,\ddot{\mathrm{C}}$	$\dot{\mathrm{H}}$ and loss.
50·52	8·60	37·17	2·44	1·27=100

The presence of carbonic acid in this mineral was long since announced by Hitchcock, who found ten per cent. in one specimen. If the uncombined silica bears any proportion to the invisible carbonates, the excess of this ingredient is sufficiently explained. We believe therefore with M. Schlieper, the mineral to be essentially identical with the mangan-augite.

4. LEPOLITE AND LINDSAYITE.

The Lepolite of Hermann[*] is a feldspathic mineral from Finland, identical in chemical formula with anorthite, but differing in having its crystals oblique or inclined to the *left*, (when the edge T : T′ is in front) instead of to the *right*. He gives for T : T′ 120°30′, P : M 93°, which is the angle between two cleavage planes. H = 6. G = 2·75–2·77. Vitreous and transparent; colorless, grayish, greenish, often brownish externally. Crystals often large, and sometimes two inches long. Composition $\dot{R}^3\dddot{Si}+3\dddot{\bar{Al}}\dddot{Si}$.

	$\dddot{Si}$	$\dddot{\bar{Al}}$	$\dddot{\bar{Fe}}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{Na}$	loss by ignition.
1. From Lojo,	42·80	35·12	1·50	14·14	2·27	1·50	1·56 = 99·69
2. From Orrijervi,	42·50	33·11	4·00	4·00	5·87	1·69	1·50 = 99·54

It fuses with difficulty on the edges before the blowpipe, and is decomposed by concentrated acids.

Hermann has also published a description of a new feldspar which he calls *Lindsayite*[†] in the same memoir with the Lepolite. The following are its characters:

Monoclinic or triclinic, T : T′ = 120°, P on the axis 65°. Crystals often of large size. H. = 4. G. = 2·83. Color, black externally, internally gray, bluish-gray, dull reddish. Subtranslucent. In a matrass yields water. Before the blowpipe fuses with difficulty on the edges. With the fluxes, the reaction of iron and silica. Analysis afforded,

	$\dddot{Si}$	$\dddot{\bar{Al}}$	$\dddot{\bar{Fe}}$	$\dot{Fe}$	$\dot{Mg}$	$\dot{K}$	$\dot{Na}$	$\dot{H}$	
	42·22	27·55	6·98	2·00	8·85	3·00	2·53	7·00	$\bar{P}$ *trace* = 100·13
Oxygen ratio	21·90	12·84	2·09	0·44	3·49	0·50	0·64	6·22	

whence he deduces for the oxygen of the water, protoxyds, peroxyds and silica, the ratio 1 : 1 : 3 : 4, and the formula[‡]

$$\dot{R}^3\dddot{Si}+3\dddot{\bar{Al}}\dddot{Si}+3\dot{H},$$

which, excluding the water, represents the composition of anorthite and also Hermann's lepolite.

Breithaupt, in volume xlvii, p. 236, of the Journal für praktische Chemie, stated that the Lindsayite was properly a pseudomorph, after lepolite. To this view Hermann objects in volume xlviii, 254, (Nov. 1849,) mentioning that lepolite contains 10 to 15 per cent. of lime and lindsayite none.

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[*] Jour. f. prakt. Chem., xlvi, 387.

[†] Jour. f. prakt. Chem., xlvi, 396.

[‡] This is only an approximation; for the oxygen of the peroxyds and silica has more nearly the ratio 2 : 3 than 3 : 4.

The constitution of the mineral, so different from all known feldspars—its 8 per cent. of magnesia, 7 per cent. of oxyd of iron, and 7 per cent. of water—entirely favor the opinion that the crystals are actually pseudomorphs of some feldspar mineral as Breithaupt suggested. Changes through pseudomorphism of the extent this would imply, and even far greater, are abundantly exemplified.

ART. XLII.—*On the Interpretation of Mariotte's Law;* by Lieut. E. B. HUNT, U. S. Corps of Engineers.

IT is readily demonstrated that in any entirely *homogeneous* medium, the component parts of which act on each other by forces varying as any function of the distance, Mariotte's law must prevail. Both elastic tension and cohesive force will necessarily vary as the density, in a medium assumed as homogeneous, quite irrespective of the law of force, the variation being expressed in terms of distance between the component parts of the medium. Whether the force be attractive or repulsive, varying inversely with the first or hundredth power of the distance, the result is the same; that *entire homogeneousness makes Mariotte's law necessary.*

To prove this: assume a perfectly homogeneous medium whose parts exert forces varying as any function of the distance. Assume in this an origin of coördinates, three coördinate axes, X, Y and Z, and three constant elementary distances, dx, dy, dz. Conceive each axis graduated by laying off its element successively from the origin outward. Through each point of graduation on either axis pass a plane parallel to the other axes: do this for each axis. The space around the origin is thus divided into elementary parallelopipeds, each of which contains a like portion of the homogeneous medium.

The force of elastic tension or of cohesion is measured by the resultant action on a unit of surface of the plane X, Y, by all the forces acting in the positive direction of the axis Z, between the parts on opposite sides of the plane X, Y. This resultant is balanced by an equal one acting in the negative direction of the axis Z. To make up this resultant, a certain number of the elementary portions of the medium conspire. It may therefore be equated with a series, each term of which expresses the positive component along the axis Z, of the force exerted between two elementary portions of the medium on opposite sides of the plane X, Y.

If now the density of the medium be varied, each term of this series will vary in the same ratio, since the quantity of matter in each elementary volume varies as the density. The density thus governs each term of the series, by fixing the quantity of matter in each elementary volume. If we call the ratio of the varying density to a standard density N, each term of the series contains N as a simple factor: or the whole series varies as N. Hence the resultant or entire elastic tension or cohesion varies as N, or as the density. This result is entirely independent of any particular law of relation between the forces and distances: and will always be true so long as the elementary volumes can be assumed as homogeneous. As dx, dy, dz, can always be taken indefinitely less than the radius of sensible activity of any assumed force, the demonstration can only fail by the parts failing to be homogeneous.

It will be seen by the above that any inference of the law of repulsive force between ultimate atoms or molecules, cannot be correctly drawn from Mariotte's law, for this leaves the primary forces involved, wholly indeterminate. We are by no means authorized to conclude that in elastic fluids where the pressure varies as the density, the molecules repel each other directly as the distance.

The demonstration now given, has a singular bearing on the atomic theory of material constitution. We know experimentally that Mariotte's law does not prevail uniformly in elastic media, while in liquids and solids it has no show of application. Hence we are bound to infer *non-homogeneousness.* Now how can homogeneousness be interrupted, except through something like an atomic constitution of media? A laminated, filamental, or molecular structure alone can produce heterogeneousness. The two first would confer special properties in certain directions, which are not found in fact. Hence a molecular constitution of matter seems entailed as an inference, from the bare fact that Mariotte's law is not universal. According to the view now presented, the elasticity of gases varies as the density, because the quantity of matter within the sphere of sensible activity varies in that ratio. As they approach the point of liquefaction, other considerations derived from the special atomic constitutions of the media must be introduced. The entire absence of a limit to the division of parts would produce that homogeneousness from which Mariotte's law becomes an inevitable inference. Such an inference, as applied to media in general, being contrary to the fact, a limit to actual division of parts must be admitted. *Any other theory than one of ultimate molecules, separated by spaces, seems to impose inferences conflicting with facts, throwing us back irresistibly into the theory of true molecular structure.*

Boston, April, 1850.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Deportment of Crystalline Bodies between the poles of a Magnet;* by JOHN TYNDALL and HERMANN KNOBLAUCH; (Phil. Mag., xxxvi, 178, March, 1850.)—The results obtained by Professor Plücker of Bonn, in his investigations upon crystals, induced us early in the month of November last to commence a series of researches in connection with this subject. Our inquiries, so far as they at present reach, form the subject of this paper.

After a long series of trials, not necessary to be recapitulated here, we arrived at the persuasion that no safe inference could be drawn from experiments made with full crystals. It appeared necessary to examine the forces attributed to crystalline bodies in detail, one at a time, removing as far as possible all influences likely to interfere with the simple action of this one.

To attain this object we experimented with cubes: we had one cut from tourmaline, in such a manner that the optical axis of the crystal ran parallel to four sides of the cube; on suspending it between the poles and closing the circuit, the optical axis set itself strongly equatorial; thus corroborating the law of Plücker, which affirms that the optical axes of negative crystals are repelled. When, however, the same cube was hung with the optical axis vertical, the influence of that axis being thus destroyed, a preference was shown to one of the diagonals of the horizontal face of the cube, not to be explained by the law mentioned: this preference was more strikingly exhibited in the case of the following two crystals.

A cube of beryl, cut similarly to the tourmaline, being hung with its optical axis vertical, one diagonal of its horizontal face set itself axial; only one diagonal could maintain this position, the other was repelled. In dichroite this phenomenon was strikingly exhibited; when hung with the middle line of the optical axes vertical, one diagonal assumed the axial position; if, however, the circuit was closed when the other diagonal chanced to lie from pole to pole, the latter seemed to experience a repulsive shock, sufficient to make the cube spin several times round upon its axis.

We do not see any possibility of referring this election of a particular diagonal to the influence exerted by the optical axis, at least in the case of beryl.

To ascertain the exact nature of this influence, we had recourse to discs, cut so that the optical axis of the crystal lay as a diameter in the plane of each. In this way the influence of mere form was totally annulled, and the pure action of the optical axis, if such existed, might be observed.

Our first discs, five in number, were taken from a semi-transparent crystal of Iceland spar, and lay at various angles to the sides thereof. In all these cases the law of Plücker was strictly verified, the optical axis being always repelled.

Four discs and one square were next taken from two transparent crystals of the spar, and suspended successively between the poles. We were by no means prepared for the reply given to these experiments; *in each of the five cases the optical axis set itself distinctly axial.*

The balance sheet of our inquiries up to the present time is this; out of eleven crystals of Iceland spar examined as above, five have obeyed the law of Plücker, while six have contradicted that law.

In determining whether the optical axis will be repelled or not, it is not necessary to cut the crystals in the manner described. A thin rhomb cloven from the crystal and ground into the shape of a disc, will decide the question. If it belong to the class whose optical axis is repelled, the line bisecting the acute angles of the rhomb will set itself axial; if to the other class, the same line will set itself equatorial.

Discs thus prepared form undoubtedly the purest means of investigating this question. The rhomb itself, however, without being ground into a disc, affords us sufficient intelligence as to the class of the crystal to which it belongs. Is its optical axis repelled, then the long diagonal of the rhomb will incline to the axial position; is the optical axis attracted, the long diagonal will stand nearly equatorial.

The same adherence of the diagonal to the axial or equatorial position continues after a thin bar containing the diagonal has been severed from the rhomb. For example, a bar containing the short diagonal of that class whose optical axis is attracted, will stand nearly axial. This fact is perhaps worthy of notice: if Iceland spar be diamagnetic, as Prof. Plücker asserts, and if the optical axis be repelled, what is it that overcomes the united action of both in the case of this diagonal? The projection of the optical axis lies in the same direction as the bar; both therefore work together, and both strive, in virtue of the two properties mentioned, to attain the equatorial position; they do not attain it, however; the bar stands almost axial.

The question, "Is the substance magnetic or diamagnetic?" necessarily lay at the threshold of all attempts to explain these phenomena. To answer this question by experimenting with the full crystal was impossible, as a diamagnetic crystal, it is well known, can set itself axially. This being evidently owing to some hidden property of the crystalline structure, we thought it might be destroyed by reducing the mass to powder. Portions of crystals of each class were finely pounded in an agate mortar; by the addition of a little distilled water the powder was made into a paste, from which small bars were constructed and carefully dried. On being hung between the excited poles, those whose optical axes were repelled stood equatorial, the others axial.

Adopting the plan already followed by Faraday, we next brought the two classes of crystals to the test of a single pole. At first, little bits of crystal were attached to the cocoon thread by means of a soft sticky kind of wax; the presence of this, however, was found to interfere with the purity of the experiment, and it was therefore abandoned; fine silver wire was next tried and also found ineligible; we next hung a straw horizontally, into each end of which a bit of crystal was thrust; but the straw was diamagnetic, and permitted no safe conclusion. Common white taper-wax was at length found exactly suited to our purpose;

it must, however, be handled with clean fingers, and even thus very little; after two or three suspensions it invariably showed signs of magnetism. We chose long thin bars of crystal and hung them vertically thus bringing the wax so far above the poles, that, on examination, it showed not the slightest trace of magnetism or diamagnetism. A former remark explains why this vertical hanging is to be preferred to horizontal; in the latter case, a rotation towards the pole, easily mistaken for an attraction, and difficult to distinguish from it, might occur with a diamagnetic body; hung vertically, however, it could be distinctly seen whether the *mass* of the crystal was attracted or repelled. The results here delivered were in harmony with those already mentioned: those whose optical axes were attracted, were attracted; those whose optical axes were repelled, were repelled.

Anxious to investigate this difference of action to the bottom, we chose two perfectly pure and transparent crystals from each class, and submitted them to chemical analysis. An experienced mineralogist was unable to detect the slightest visible difference between these crystals; the analysis, however, showed that those whose optical axes were attracted contained protoxyd of iron in considerable quantity, while those whose optical axes were repelled contained no trace of this metal.

Here, then, we have two crystals perfectly alike in optical respects, but chemically different; the change in the position of the optical axis between the poles being doubtless due to this difference. This seems to reduce that position to a mere function, so to speak, of the chemical nature of the substance. Could a salt of iron be introduced as an isomorphic substitute for some other constituent in the whole class of diamagnetic crystals, it is exceedingly probable that the position of the optical axis between the poles would in most of these cases be reversed, and this without in the slightest degree interfering with the optical properties of the crystal. It is even likely that Nature, as in the case before us, furnishes many examples of this isomorphic substitution. If this be true, then the position of the optical axis between the poles is a mere accident, and the introduction of it can only serve to render this already difficult subject unnecessarily complex.

On bringing a circular disc of gutta percha, which, in its manufacture, appeared to have a fibrous structure imparted to it, between the excited poles, the direction of these fibres set itself strongly axial. This action was so decided, that a parallelogram, three-quarters of an inch long and half as wide, with the fibres crossing it transversely, set itself stiffly equatorial. This can by no means be referred to the distance of the parallelogram from the poles, or to any other of those circumstances by which diamagnetic action is said to be exhibited; our voltaic power varied from one to twenty cells of Bunsen's battery, but the result remained specifically constant; further, on being hung edgeways, the parallelogram stood strongly magnetic; and when one pole was removed, the whole mass was attracted by the other.

Whence, then, this apparent diamagnetism of the gutta percha? The answer to this question will perhaps throw a light upon the complicated phenomena exhibited by crystals generally. The equatorial position of the gutta percha is manifestly due to the comparative facility with which the magnetic force can act in the direction of the fibre. Let us suppose the parallelogram suspended, and the circuit closed; every point of its substance is now affected, but not with equal force in all directions; in the direction of the fibre the action is strongest, and may be represented by the longer diameter of an egg, in the centre of which the point may be imagined. All lines drawn from the centre to the shell will represent the amount of the magnetic force in their various directions. On this assumption the equatorial position is readily explained; and the necessity of the parallelogram, when hung edgeways, to set itself axial, is also manifest.

As may be expected, when the parallelogram is made very long in comparison to its width, the long diameter of our hypothetical egg, is overpowered by the united action of a number of short ones, and the oblong stands axial.

We have succeeded in obtaining analogous results with ivory, which, though diamagnetic, can be so cut that it stands almost axial. The anomaly is explained by reference to the structure of the tooth, which modifies, in certain directions, the diamagnetic power. By attending to these circumstances, we have been able, with these two substances, gutta percha and ivory, to imitate almost all the experiments which we have made with both classes of crystals.

If we suppose the shorter diameter of an ellipse to coincide with the straight line formed by the intersection of any two surfaces of cleavage, and the ellipse to rotate around this diameter, an oblate spheroid will be the result. Conceive lines drawn through the centre of this figure and terminated by the surface, to represent the amount of magnetic or diamagnetic force in the direction of these lines, and we have an hypothesis of magnetic or diamagnetic action within the crystal, sufficient, not only to account for every fact noticed in this paper, but for numerous others, the discussion of which we refer to a future occasion.

Extending this principle to the intersections of the three surfaces of cleavage, we obtain a resultant which falls in the direction of the principal axis of the crystal, or of the optical axis. The position of that resultant between the poles will depend solely upon the magnetism or diamagnetism of the crystal, and in nowise upon the fact of its being negative or positive, as asserted by Professor Plücker.

It is highly improbable that our representative spheroid will be of a constant shape in all crystals: in the case of gutta percha we assumed it formed by the rotation of a semi-ellipse round its longer axis, or what is commonly called prolate; in the case of Iceland spar it is oblate; in common iron it would be a sphere, as here the magnetic force appears to act equally in all directions. Every crystal will doubtless modify it in a manner peculiar to its own substance and structure. Future experiments will perhaps enable us, in many cases, to determine the numerical values of the long and short diameters of these spheroids.

From these considerations it would follow, that M. Plücker, in attempting to refer the facts observed by Mr. Faraday* to the optical axis, inverts the right course of proceeding; the attraction or repulsion of this axis being a secondary result, depending first of all upon the magnetism or diamagnetism of the substance, and secondly upon the manner in which either force is modified by the peculiar structure of the crystal.

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* Phil. Mag., Jan., 1849, p. 75.

The conducting power, so to speak, of Iceland spar for both magnetism and diamagnetism appears to be in directions perpendicular to the lines of cleavage. If these views be correct, the optical axis can no longer be regarded as the prime agent in the production of the phenomena which we have been considering; we shall no longer seek the explanation of new facts in the hypotheses of new forces, but rather in modifications of the old.

Marburg, January, 1850.

2. *Arsenic in the deposit from Mineral Waters;* by M. J. L. Lassaigne, (Journ. de Chem. Med., Sept., 1849; Phil. Mag., Dec., 1849.)—The large quantities of arsenic recently discovered in certain chalybeate waters, have made it a matter of much interest to determine the state in which the arsenic exists, and its effects upon the animal economy.

The deposit from the waters of Wattvillier (Haut Rhine) yielded 4·42 per cent. of arsenic acid, equivalent to 2·8 per cent. metallic arsenic. Forty grammes (about 600 grains) of this deposit were administered to a dog in two doses, the animal showed not the slightest uneasiness, ate as usual, and, in short, was uninjured by a dose equivalent to 26·52 grains arsenic acid or 16·8 grains metallic arsenic.

From this and another experiment of similar character, the author infers, that the poisonous property of the arsenic is destroyed in these deposits by the combination with peroxyd of iron—confirming the value of peroxyd of iron as an antidote to arsenious and arsenic acids.

[It is worthy of remark, however, that the recent deposit from chalybeate water is not without serious effect upon the human system, as is shown by the following case which was brought to our notice. Two gentlemen while drinking the water of a celebrated chalybeate spring thought to add to its strength by mixing with it several teaspoons full of the fresh deposit. In a very short time such alarming symptoms manifested themselves as to require medical aid. These symptoms were violent headache, throbbing in the temples, &c., and were evidently due to an over dose of iron. The parties soon recovered, but in the more plethoric of the two the effects were sensible for several days.

The same quantity of *dry* peroxyd of iron—such as is erroneously called carbonate of iron, might have been taken with impunity. No more striking instance of the difference in effect between the moist freshly precipitated oxyd and the dry could be given.]

G. C. Schaeffer.

3. *On the reduction of Chlorid of Silver;* by M. Wittstein, (Buch. Rep., vol. ii, in Chem. Gaz., Sept., 1849.)—The author prefers the reduction by charcoal. Two parts of chlorid of silver are well mixed with one part moist charcoal powder and poured into a black lead or other crucible with a smooth surface. The crucible is loosely covered and ignited until a quarter or half hour after the muriatic acid has ceased to appear. The outside of the crucible being cleaned it is to be inverted over a sheet of paper, and if any of the contents adhere they may be removed with a feather. The carbonaceous mass is then gradually added to 3 parts nitric acid, sp. gr. 1·20, in a convenient flask, and the solution is completed by a gentle heat.

As it is not easy to extract the whole of the silver, the mass need not be washed very long and the residuum may again be employed in another process to avoid loss. The impurities derived from the charcoal are trifling in amount; lampblack of course answers still better.

The author considers that the reduction is effected in reality by hydrogen, as only muriatic acid and no chlorine is given off.

G. C. S.

4. *On the Chemical Composition of the Fluid in the Ascidia of Nepenthes;* by Dr. A. Voelcker, (Phil. Mag., Sept., 1849.)—The fluid of this, and similar secretions as in Sarracenia, &c., is commonly said to be pure water. Dr. Turner found on evaporating, a minute quantity of crystals supposed to be binoxalate of potash, while the odor of boiled apples given out indicated the presence of organic matter. The author examined eight different samples from various gardens and in most cases from unopened pitcher plants. In all the cases litmus paper gave an acid reaction. The same odor as that mentioned by Dr. Turner was observed during evaporation. The quantity of solid matter, as might be expected, varied considerably—from ·27 to 1 per cent. No volatile acids were present and no oxalic acid.

The dry residue from several samples united, contained about 38 per cent. of malic and a little citric acid, 50 p. c. chlorid of potassium; the remainder consisted of soda, lime and magnesia.

These experiments show this to be, as botanists have already demonstrated, a true secretion, containing *some* of the inorganic materials of the plant; but it is remarkable that not a trace of sulphuric acid could be detected, and yet it is hardly possible that sulphates are entirely wanting in the plant. G. C. S.

5. *Chlorine and Oxygen from Chlorate of Potash;* by Dr. Vogel, (Buch. Rep., vol. iii, in Chem. Gaz.)—The author states that chlorate of potash repeatedly crystallized furnishes a pure gas, and ascribes the impurity to the presence of some perchlorate (hyperchlorite?).

[It is generally understood that oxygen from the mixture of peroxyd of manganese and chlorate of potash, is always contaminated with more or less chlorine, in which case the above precaution would be of no use.

The supposed easy preparation of pure chlorate is at the foundation of numerous determinations of chemical equivalents, and in particular that of chlorine.] G. C. S.

6. *Action of Potash upon Caffeine;* by A. Wurtz, (Comptes Rendus, Jan., 1850.)—A boiling concentrated solution of potash dissolves caffeine and disengages a considerable quantity of methylamine.

This confirms the supposition made in the last No. of this Journal, p. 282, that the base formed by Rochleder in the decomposition of caffeine by chlorine was methylamine. M. Wurtz also notices that the composition of the platinum salt is identical with that of the corresponding platinum salt of methylamine. G. C. S.

7. *Separation of Butyric, Valerianic and Acetic Acids;* by J. Liebig, (Liebig's Annalen, Sept., 1849; Chem. Gaz., Jan., 1850.)—The simultaneous occurrence of these acids renders an easy and economical process for their separation exceedingly desirable. This desideratum is fully answered by the plan proposed by Prof. Liebig. A part of the mixture of acids is saturated with potash and soda, or the re-

mainder added to it and distilled. If butyric and valerianic acids only are present, a portion of one or the other is at once obtained pure. If the alkali added is not sufficient to neutralize the whole of the valerianic acid, the distillate is a mixture, and the residue is a pure valerianate. If the alkali is more than sufficient to neutralize the valerianic acid, the residue is a mixture of valerianic and butyrate, but the distillate is pure butyric acid.

The mixtures remaining may be treated in the same way, and a new portion obtained pure.

Acetic acid, although more volatile than the other two, is not expelled by them from a partially saturated solution, owing to the formation of an acid acetate. Either valerianic or butyric acid may be distilled from this salt without intermixture with acetic acid. Where all these acids are present, the partially saturated mixture is to be distilled, and if any acetic acid is found in the distillate the process is to be repeated. Acetic acid is thus removed and the other two may be separated as above.

G. C. S.

8. *On the Production of Organic bases from Vegetable substances containing Nitrogen;* by Dr. J. Stenhouse, (Liebig's Ann., May, 1849; Chem. Gaz., Oct. and Nov., 1849.)—Reasoning upon the fact that fossil coal has yielded four bases besides ammonia—the author proposed to examine the products of the dry distillation of nitrogenous vegetable matter, and as these substances could not easily be obtained pure in large quantity, he operated directly upon seeds, &c., which are known to contain most of the nitrogen of plants. A large quantity of common beans was distilled in an iron retort. The product resembled that from animal matters, containing acetone, acetic acid, &c., with tarry matter and a large quantity of ammonia and oily bases. These latter were, with some difficulty, obtained in a state of purity, but the result was an evident mixture, the boiling point rising from 226° F. to 428°. The larger portion passing over between 302° and 311°, a tolerable quantity of an oil of constant boiling point was obtained.

Notwithstanding the difference in the bases indicated above—their properties are otherwise quite similar. They are colorless and transparent, of high refractive power, with pungent aromatic taste and odor. The more volatile are also more soluble in water, but all of them dissolve readily in alcohol and ether. The alkaline reaction upon test paper is very strong, and a rod moistened with hydrochloric acid held over them produces white fumes. The salts are generally crystalline; the double platinum, gold and mercury chlorids are readily obtained; not a trace of aniline could be detected.

The analysis of the oil boiling between 302° and 311°, gave the formula $C_{10}\ H_6\ N$, but this must be considered only as an approximation. The formula is nearest to that of nicotine; but the properties are rather those of picoline, discovered by Dr. Anderson.

An examination of oils boiling at very different temperatures, gave almost the same per-centage of carbon and hydrogen. May not some of these be merely polymeric modifications of the less volatile bases?

Oil cake required a higher heat for its distillation than the bean, and a smaller quantity of bases was obtained; wheat furnished a still smaller quantity, but the product was more volatile. Peat gave a larger quantity, but the products of the distillation of solid wood furnished hardly any.

To avoid the high heat necessary in distillation, by which the bases are decomposed, and the quantity of ammonia increased—experiments were made by boiling the substances with alkaline solutions; the products were nearly the same but more free from impurity. Flesh and guano were also tried, and the action of sulphuric acid upon beans, with like results.

The author proposes putrefaction as a still more eligible process for the alkaloids, as the action is less energetic. The fact that beans and bones do not yield the same products by distillation, is adduced as evidence that the vegetable and animal substances having the same composition are yet not identical. G. C. S.

9. *Preparation of Hydrobromic and Hydriodic Acids;* by E. H. Mène, (Comptes Rendus, April, 1849; Chem. Gaz., July, 1849).—The process now proposed for these two acids is free from objection, being neither costly, difficult nor dangerous, as are the usual modes.

In this process, crystallized hypophosphite of lime, obtained in preparing phosphuretted hydrogen from phosphuret of calcium, may be used, but from its being more readily obtained, sulphite of soda is to be preferred. The crystallized sulphite is to be first dipped in water and the iodine or bromine added to it in a suitable vessel. The reaction is aided by heat, and the gases are obtained pure, if a cotton or asbestus plug is placed in the neck of the vessel to intercept vapors of bromine or iodine.

The sulphite aids the decomposition of water by the iodine or bromine, the latter taking the hydrogen, the former the oxygen.

The proportions for the above process are 1 water, 3 iodine or bromine, 6 crystallized sulphite of soda. G. C. S.

10. *Passage of Hydrogen Gas through solid bodies;* by M. Louyet, (Ann. de Chim. et de Phys., Sept., 1849.)—M. Louyet, finds that a horizontal current of hydrogen from a capillary jet under a pressure of 40 to 45 inches of water, will pass through a sheet of paper, continuing as a current on the other side, inflaming or igniting spongy platinum, as if no obstacle existed.

Gold, tin and silver leaf, even when double, exhibit the same property, as also a thin film of gutta percha; but the thinnest glass which could be blown was found impermeable. G. C. S.

11. *On the presence of Silver, Lead and Copper in Sea-water, and in Plants and Animals;* by MM. Malaguti, Durocher and Sarseau, (Comptes Rendus, Dec., 1849; Phil. Mag., Feb., 1850.)—MM. Malaguti and Durocher having proved the wide diffusion of silver in metallic minerals, particularly in the sulphurets, which are converted by salt water into chlorids, the present research was undertaken with a view to ascertain the extent of the distribution.

Sea-water taken at a distance of some leagues from St. Malo, was found to contain ·000,000,001 of silver; the ash of Fucus serratus and ceramoides contained ·000,001. Rock salt of Lorraine was found to contain silver, indicating its presence in the ancient ocean.

This wide distribution of the metal induced a search for it in the ashes of terrestrial plants and in animals, the blood of them being saturated for the experiment. In both cases silver was found. Its presence could not be distinctly proved in the ashes of coal.

Lead and copper could not be detected in sea-water, but the ashes of several species of Fucus contained ·000,018. G. C. S.

12. *Ruthenium.*—The atomic volume of Ruthenium has been found by Claus to be identical, or nearly so, with that of Rhodium, or 651·96, see table, page 220.

II. MINERALOGY AND GEOLOGY.

1. *Description of the Vermiculite of Milbury, Mass.;* by Dr. C. T. JACKSON, with an analysis by Mr. RICHARD CROSSLEY, (communicated by Dr. JACKSON.)—This mineral was first noticed in Milbury by Dr. Thomas H. Webb of Providence, R. I., and was described by him in the American Journal of Science in 1824, vol. vii, p. 55. Dr. Webb gave it the name it bears, which is very descriptive of its remarkable action under the influence of heat. It occurs in small scales resembling green talc disseminated throughout a mealy magnesian mineral of an ash grey color, and resembling a decomposed talcose rock. The vermiculite occurs in small scales, rarely more than one-sixth of an inch in diameter, and having no well defined lateral crystalline edges; but still they are obviously imperfect crystals and probably hexagonal prisms. They split readily into thin laminæ, like talc, and are flexible, but not elastic. Hardness 1·; sp. gr. according to Mr. R. Crossley, 2·756, the mineral having been rendered dry previous to being weighed. Color dark olive green by reflected light, with a pearly and greasy lustre; by transmitted light, color apple green. Translucent, and sub-transparent in thin scales. Before the blowpipe a thin scale of the mineral suddenly exfoliates and swells into a cylinder or prism nearly *one hundred times its original length!* This exfoliation takes place at a temperature between 500° and 600° F., and not at a temperature of 300° F., hence it is not wholly due to interposition of water between the laminæ of the crystals.

In a glass tube closed at one end, on heating until exfoliation takes place, a certain portion of water is given off, but on raising the heat to redness a still larger quantity is obtained. This water restores the blue color to litmus paper, that had been reddened by acids, and is therefore slightly alkaline. The expansion of vermiculite by heat is so sudden and powerful as to burst a glass tube filled with it, producing an audible explosion and scattering the glass to a distance.

In the platina forceps a scale of the vermiculite melts readily into a yellowish green glass. With carbonate of soda it fuses to an opaque brown bead. With borax it dissolves readily, giving a yellow glass while hot, which becomes colorless when cold.

With salt of phosphorus, it dissolves giving a transparent glass, which is yellow while hot, and colorless when cold, and becomes somewhat milky white. It is decomposed by chlorohydric and sulphuric acids. Mr. Crossley used a mixture of these two acids in decomposing the mineral for separation of its ingredients; having previously ascertained that its decomposition by acids was complete.

Clean scales of the mineral were selected with great care by Mr. Crossley, who obtained the following results—

Silica, . . .	35·74	containing oxygen =	18·56	ratios = 6·
Alumina, . .	16·42		7·66	2·
Protoxyd of iron, .	10·02		2·28	4·
Magnesia, . .	27·44		10·62	
Water, . . .	10·30		9·15	3·
	99·92			

Which gives approximately the following formula,*

$$2\bar{Al}\,\dddot{Si}+4\dot{Mg}^3\,\dddot{Si}+9\bar{H}$$

which is the formula given by von Kobell for *Pyrosclerite.*

Vermiculite therefore does not approach Pyrophyllite, which, according to the analysis of Hermann, gives the formula,

$$\dot{Mg}^3\,\dddot{Si}^2+9\bar{Al}\,\dddot{Si}^2+9\bar{H}$$

Mr. Crossley has devoted much time and attention to this analysis, and I am satisfied that it has been correctly made. The only subject for farther research is the cause of the very remarkable exfoliation of this mineral when exposed to heat. I ascertained the temperature at which the exfoliation takes place by heating the mineral on paper and on lead. It fully exfoliates below the fusing point of sheet lead, but not on a paper card, until it takes fire.

2. *On the Blowpipe characters of the Mineral from the Azores identified with Pyrrhite by J. E. Teschemacher;* by A. A. Hayes, (communicated.)—I received enough of the Pyrrhite from Mr. Teschemacher for the following trials. It proves to be a (columbate) niobate of zirconia, colored apparently by oxyds of iron, uranium and manganese. The following are its characters in the blowpipe flame. On the first impulse of heat, the assay becomes darker colored, its fine red color returning as the mineral cools; and this character may be observed, even after it has been highly heated for a long time. At the melting point of cast iron in the reducing flame, it becomes permanently darker and brown; on platinum wire, the assay dissolves in six bulks of fused borax and affords a clear colorless glass, which barely retains its transparency on cooling; becoming instantly opaline, or opaque by flaming. The oxydating flame causes opacity in a hot clear globule removed from the reducing flame. Phosphoric salt in the reducing flame affords a clear glass with one sixth its bulk, and when reduced, the glass is green. The oxydating flame colors the glass yellow. With one-fourth its bulk the fused salt dissolves the assay slowly, and the glass remains clear. In the reducing flame with twelve times its bulk of soda, the assay dissolves; some clear portions are seen while the globule is hot, but on cooling, opacity precedes the crystallization of the globule. When by continued reduction, the soda is partly evaporated, a gray brown slag remains, which cooled from the oxydating flame gives the green color, indicating oxyd of manganese.

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* Considering $\bar{Al}$ and $\dddot{Si}$ as replacing one another, the analysis gives very exactly the formula $4\dot{Mg}^3(\dddot{Si},\bar{Al})^2+9\bar{H}$.—J. D. D.

Decomposed by much soda and the resulting mass treated with nitric acid, a heavy white insoluble powder remains. Boiling water causes the heavy powder to take a flocculent form, which is retained. This powder exhibits with tests, all the characters of (columbic) niobic acid. The acid solution when mixed with carbonate of ammonia remains clear; heated, some iron oxyd falls, while a light yellow tint is retained by the fluid; oxalic acid causes the separation of a white earth, which, heated with sulphuric acid to destroy oxalic acid, dissolves, giving a fluid, forming with potash before complete neutralization, a white double salt, which has the characters of that from zirconia, but may contain oxyd of cerium also. The oxalate as first formed does not afford, when heated, the cinnamon brown color, characteristic of deutoxyd of cerium.

The extremely small portion of the mineral operated on forbids the expression of certainty respecting the bases, and although inclining to the opinion of the existence of cerium from the red color of the crystals, I am not in possession of any facts proving this point.

3. *On the Red Zinc Ore of New Jersey;* by A. A. Hayes, (communicated to one of the Editors.)—Some recent trials on the red oxyd of zinc, confirm my earlier statement that the manganese is in a protoxyd state, *mixed* with the oxyd of zinc. The object was however to separate the peroxyd of iron, so as to show that its power of coloring confers on the oxyd of zinc the blood red color seen in fine specimens. In the trials, that variety of scaly peroxyd of iron, *which is produced when chlorid of iron is decomposed by vapor of water*, was obtained, and this oxyd, *being transparent and blood-red*, gives, by being interleaved with the crusts of zinc sublimate, the red color: the evidence was conclusive.

4. *On the existing Mineral Localities of Lewis, Jefferson, and St. Lawrence counties, New York;* by Dr. F. B. Hough.—From the great number and variety of mineral species, which were discovered during the course of the State Geological Survey, in the northern part of New York, in addition to those that were known before, and have been discovered since, the mineral localities of that section have attained a merited notoriety, among amateur collectors, and scientific mineralogists.

Many of the localities have become exhausted, and others have been discovered, while there are yet others which have been attributed to these counties through mistake. A concise account of existing localities seems to be especially desirable.

Lewis County.—*Magnetic iron ore*, associated with sulphuret of iron, occurs in Greig; *bog iron ore*, in Watson, Diana, and New Bremen; *specular iron ore* in Diana, and *iron sand* on the sandy margins of most of the streams and lakes, throughout the primary regions in the county. *Calcareous tufa*, abounds in many of the springs that issue from the limestone formation; particularly in Lowville. *Tremolite* occurs frequently in *boulders* but not *in situ*, in the county. A mass weighing about a ton occurs a mile southeast of the village of Collinsville, in West Turin.

Wad occurs in the southwestern part of the town of Martinsburg, in nodules disseminated through the soil of a swamp. The masses are from one to three inches in diameter; pulverulent externally, but exhibiting a glossy fracture when broken. It soon crumbles on exposure.

In the town of Diana, the following minerals occur abundantly. *Tabular spar*, with *green coccolite*, *nuttallite*, *variegated serpentine*, *rensselaerite*, *black pyroxene*, *feldspar*, in crystals variously modified, and a singular mixture, apparently of graphite, chlorite, and specular iron ore, which has been strangely considered an "ore of silver." Associated with the foregoing, but in less quantities, are *sphene*, crystals of *sulphuret of iron*, and very rarely *zircon*.

The vicinity also affords surfaces spangled with minute crystals of *quartz*, upon a coarse variety of *agate*, and *calcedony:* and a *crystalline limestone* of a crumbling texture, and a sky-blue color.

Opake crystals of *quartz*, of large size, are frequent near the serpentine locality. Most of the localities in Diana, occur along the line of transition between the primary, and the sedimentary formations, and within two miles of the little village of Natural Bridge.*

The following localities attributed to Lewis county are exhausted, or the mining operations which produced them have been discontinued, so that specimens can be no longer procured. None of these mines will ever in any probability be reöpened.

Galena, occurred in the lead mines three-fourths of a mile N.W. of Martinsburgh village. It exhibited various forms, intermediate between the cube and octahedron. It occurred also arborescent, pseudomorphous, fibrous and massive. With it were associated *carbonate of lead*, *blende*, *sulphuret of iron*, *calcareous spar*, in the forms represented in the Mineralogical Report of the Geological Survey of New York, figures 60, 62, 71, 73, 74, 75, and 76, in which last form the sides of the prism were nearly obliterated by the approximation of the terminal planes;—also very rarely small cubes of *fluor spar*.

Near Lowville village, there formerly occurred *galena*, in minute crystals, associated with *sulphuret of iron*, *calcareous spar*, often beautifully crystallized, and magnificent specimens of *green fluor spar*, crystallized in small cubes of nearly uniform size, which were never modified by replacements upon their edges or solid angles.

Unfortunately this mineral was usually so penetrated by sulphuret of iron, as to be rapidly destroyed by the efflorescence of the latter. It may be possible to procure more of this mineral, but the expense would be great, and success very uncertain.

With the exception of an occasional boulder, containing *epidote*, *colophonite*, *tourmaline*, *garnet*, &c., the foregoing is a complete list of the minerals found in Lewis county. For a more particular account of the geological relations of these minerals, reference may be made to the "Am. Jour. of Agriculture and Science," Nos. xiii and xiv, pp. 267–314.

JEFFERSON COUNTY.—*Agaric mineral* abounds in the caverns of Watertown, and Pamelia.

Cacoxenite. Sterling iron mine, Antwerp.

Calcareous spar appears in numerous and peculiar forms of crystallization in the town of Antwerp, particularly in the vicinity of Oxbow village, and on the shores of Vroman and other lakes.

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* Near the Natural Bridge, a few years ago, was opened a mine of *copper pyrites*, which occurred thinly disseminated through gneiss. It was unpromising, and after some outlay, operations were suspended. In one of the excavations were found traces of *coal*, much resembling anthracite.—S. W. J.

Saccharine limestone forms immense ledges in Antwerp, &c.

Theresa affords several localities of calcareous spar.

Calcareous tufa. Pamelia, Adams, &c., along the range of transition limestones.

Carbonate of iron crystallized at the Sterling iron mine, Antwerp.

Feldspar. In Alexandria, in great abundance. Antwerp, &c.

Fluor spar. Theresa, in several localities. The celebrated locality at Muscolongue lake, in this town, is nearly or quite exhausted. In Adams, associated with sulphate of barytes. It occurs here in delicate shades of pink and green.

Hornblende. Theresa. Alexandria.

Idocrase, in minute crystals, on the banks of Vroman's lake, in Antwerp near the village of Oxbow. It occurs in an impure limestone, with sphene, &c.

Iron, (*bog ore.*) Wilna, Antwerp, &c. In the latter town, it occurs in a deposit in which an immense variety of organic substances are mineralized by it. It is near the village of Oxbow.

Iron, (*specular ore.*) Theresa, Antwerp, and Philadelphia. It furnishes a vast amount of iron annually.

Mica, in Antwerp, near Vroman's lake crystallized in hexagonal prisms, often six inches in length.

Most "mineralogists" refer to Henderson, in this county, as a fine locality. After many inquiries I am forced to believe that none occurs in the town. This town as well as most of the adjoining ones, *is underlaid by transition limestone,* and no primary rock can occur in it, larger than *common bowlders.*

Pargasite. Antwerp, near Muscolongue lake.

Pyroxene, of a light color, near Vroman's lake, in Antwerp, associated with crystals of mica, and sphene.

Quartz. Antwerp and Theresa, associated with specular iron. Near Vroman, and other lakes, in the northern part of the county.

Scapolite. Rarely in slender crystals in Antwerp, on the farm of David Eggleson.

Serpentine. Theresa, Antwerp, of various shade of white and black. (Rensselaerite?)

The *brecciated* or *porphyritic* variety, is a constant associate of specular iron, in Antwerp, Theresa, &c.

Sphene. In Antwerp near Vroman's lake.

Sulphate of barytes. Pillar Point, in Brownville, near Sackett's Harbor, near North Adams, in a vein which has been traced nearly a mile. A porous coralloid variety, occurs in Antwerp near the village of Oxbow. It is filled with vermicular cavities, and stained with iron.

Sulphate of strontia. Theresa, or Alexandria, in beautiful crystalline masses; of a snow-white color.

Sulphuret of copper and iron. In Antwerp, on banks of Vroman's lake.

Sulphuret of iron. Antwerp, associated with specular ores of iron.

Sulphuret of nickel. Sterling mine, Antwerp, in brilliant capillary crystals.

Tourmaline. In large crystals. Alexandria.

Tourmaline, (yellow.) Antwerp, in limited quantites.

Terenite, has been attributed to this county, (Antwerp,) but its locality is lost.

Tremolite, occurs in minute quantities, occasionally in cavities of Black river and Trenton limestone.

In addition to the foregoing the usual variety of minerals, occur scattered in detached bowlders, over the country.

St. Lawrence County.—The uncommon splendor and variety of minerals brought to light by the mania for mining speculations, which prevailed throughout the county about ten or twelve years since, has rendered St. Lawrence county proverbial for its mineral localities.

Most of these enterprises having proved unprofitable, and often ruinous, to those engaged in them, have been abandoned, and the iron mines are the only ones that are now wrought. No probability exists of any of them being ever resumed, and consequently many minerals formerly found here can be no longer procured at their localities. This applies especially to the *lead mines* of Rossie, which were discontinued about ten years since.

A vein of spar was often the only inducement to engaging in a mining operation, and many elegant specimens were obtained in these enterprises, which can no longer be procured. The following minerals occur at present in the county, being all of them more or less accessible, and abundant, with the exceptions specified.

Agaric mineral, in a calcareous spring, Governeur.

Apatite. Rossie, Hammond, &c. Good specimens readily procured with little labor and expense. A new locality was accidentally discovered in Rossie, about two miles from the village of Oxbow, in the fall of 1849.

Albite. Governeur, Fowler, &c., in granite.

Agate. A coarse variety in Fowler.

Arragonite. Iron mines, near Somerville.

Automolite has been attributed to Rossie. Its existence there is very doubtful. Locality unknown.

Babingtonite. Locality unknown. Said to occur in Governeur. After much search in the spot where it was said to occur, I am inclined to believe that if it was ever found there, it has become exhausted.

Blende. Morristown, DeKalb, Fowler, Macomb. Several of its localities are now inaccessible.

Calcareous spar. Governeur, Rossie, Russel, &c. The large limpid crystals from Rossie, are no longer procurable.

Calcareous tufa, frequently met with in calcareous springs.

Calcedony. Fowler.

Carbonate of iron. Iron mines, Rossie, magnificent specimens occasionally found; those of ordinary quality frequent.

Chondrodite. "Governeur near Somerville." This locality was a *boulder*, and has been carried off. Frequent in Rossie, near Yellow lake, in detached masses.

Dolomite. Hammond.

Feldspar. Rossie, Governeur, Hammond, &c.

Feldspar. *Labradorite* occurs near Ogdensburgh.

Fluor spar. Morristown, Governeur, associated with heavy spar.

Galena. No longer procurable at the localities without mining.

Graphite. Rossie, Governeur, Dekalb, &c.

Hematite. Iron mines, Rossie, Governeur, &c.

Hornblende. Dekalb, Rossie, Governeur, Potsdam, Pierrepont, &c.

Hyalite. Quartz, with the appearance of hyalite, is associated with apatite and zircon, in Hammond and Rossie.

Idocrase. Governeur.

Iron, (*bog ore.*) Hermon, Brasher, Fowler, Governeur, Canton, &c.

Iron, (*magnetic.*) Edwards, Russel, Pierrepont.

Iron, (*specular.*) Hermon, Rossie, Governeur, Edwards, Canton, Pierrepont and Fowler. Often beautifully crystallized and associated with interesting minerals. It is the most important iron ore in the county.

Mica. Governeur, near Somerville, in serpentine. Edwards, Macomb, Potsdam, Rossie, &c.

Pargasite. Rossie, Hammond, Russel, Hermon, &c.

Pearl spar. Banks of Oswegatchie in Rossie.

Pyroxene. Governeur, Rossie, Hermon, DeKalb, &c.

Quartz. Usually associated with specular iron ore. Rossie, Russel, Governeur; in Governeur the smoky variety occurs. In Russel the dodecahedron with triangular faces. Spongy quartz occurs in DeKalb.

Rutile, attributed to Governeur. No locality known in that town, or in the county.

Scapolite. Governeur, in great abundance, in primary limestone, associated with quartz, pargasite, and *formerly* with apatite. The latter mineral has become exhausted.

Satin spar. Rossie, Fowler, Pitcairn. In each of its localities it is associated with serpentine.

Serpentine. Governeur, near the tremolite locality. Edwards, Pitcairn, Rossie, DeKalb, Hermon, Fowler, Russel, Canton, Fine, Colton. In most of the above towns, serpentine occurs in ledges, and is associated with primitive limestone.

Rensselaerite, occurs in nearly all the above mentioned towns, it is of every shade of white, black, green, &c., and occurs crystallized, radiated, fibrous, laminated, and cleavable. The *brecciated* variety, is a constant associate of the specular iron ore, and in some localities, as at Kearney mine, near Somerville, it is beautifully variegated. The texture of this variety is so fragile, as to fall to pieces upon receiving a slight blow from a hammer. Varieties which have received the name of *soapstone*, and have been wrought into various ornamental articles, occur in Fowler, Edwards and Russel. It is often of a snowy whiteness, and passes by insensible gradations into talc, and tremolite.

Sphene. Rossie, in pale red and brown crystals, with apatite, pargasite and crystallized feldspar. Governeur, in black crystals, in granite.

Spinelle. Associated with mica, in serpentine, in the town of Governeur, near the village of Somerville. Crystals of a large size, (one and two inches on a side,) have been found here, but they are rare. Small brilliant crystals are common. The small crystals are very perfect, but the larger ones are much blended with the matrix. Color pink and reddish brown.

Sulphate of barytes. Governeur, in highly crystalline and fibrous varieties. Fowler, Rossie, DeKalb.

Sulphate of strontia formerly found in lead mines, Rossie. Locality inaccessible.

Sulphuret of iron. Rossie and Governeur, in iron mines. Fowler, Canton, &c.

Sulphuret of copper and iron. Canton, Fowler, Macomb, &c.

Tourmaline. Rossie, Governeur, Hermon, &c. Often of a brown and yellow color.

Tremolite. Governeur, in splendid crystalline and fibrous masses, associated with primary limestone, DeKalb. In Fowler, a purple variety occurs. Rossie, Hermon, Edwards, &c.

Zircon. Hammond and Rossie. Coarse opake specimens may be obtained with facility. Beautifully crystallized and very perfect specimens often procured. It occurs in primary limestone, associated with apatite, feldspar, loxoclase (?) hyalite, graphite, &c. The principal locality is on the farm of Mr. Hardy. It has been improperly attributed to the farm of Mr. Robinson.

5. *Isomorphism of Miargyrite and Augite.*—Miargyrite crystallizes in monoclinic forms, and the angles as given by Haidinger are M : M = 86° 4′, P : M = 101° 6′. Augite has M : M = 87° 6′, P : M = 100° 25′. The augite group of isomorphs with this addition includes, augite, pyroxene, glauber salt, acmite, hornblende and miargyrite.* Calculating the atomic volume of miargyrite we have

$$A = 3762{\cdot}8 \div 5{\cdot}234 \text{ (sp. gr.)} = 718{\cdot}9 \qquad C = 718{\cdot}9 \div 6 = 119{\cdot}8$$

The result 119·8 divided by $2\frac{1}{2}$, gives 47·92, which is very near the atomic volume of the augite series. If antimony is taken as a double atom, it gives 718·9 ÷ 7 = 102·7, which is a little more than double the number for the augite series. Moreover, the whole number 718·9 is not much above the number for Hudsonite. We repeat the numbers here for comparison.

		A.	B.	C.
Pyroxene,	1st var., $(\dot{Ca}, \dot{Mg})^3 \dddot{Si}^2$	637·	127·4	45·5
	2nd var., $(\dot{Ca}, \dot{Mg}, \dot{Fe})^3 \dddot{Si}^2$	645·2	129·	46·1
	3d var., Hedenbergite,	673·4	134·7	48·1
	4th var., $\dot{Fe}^3 \dddot{Si}^2$	674·7	135·	48·2
	5th var., $\dot{Mn}^3 \dddot{Si}^2$	684·8	136·9	48·9
	6th var., Hudsonite,	706·0	141·2	48·9
Miargyrite,	- - - -	718·9		119·8 (or 102·7)
Acmite,	- - - -	918·5	183·7	48·34
Hornblende,	1st var. - -	971·6	188·8	48·58
	2nd var., aluminous, -		155·95	47·25
	3d var. " -		138·4	48·43
	4th var. -		144·0	48·24
Borax,	- - - -	1391·6	107·0	46·38
Glauber salt,	- - -	1290·5	107·54	49·6

J. D. D.

6. *Analysis of the Schorlomite of Shepard*; by C. RAMMELSBERG, (Poggendorf's Annalen, lxxvii, 123, 1849).—Rammelsberg finds this mineral from Arkansas to consist of

	Silica.	Titanic acid.	Lime.	Protoxyd of iron.	Magnesia.
1.	26·09	17·36	31·12	22·83	1·55 = 98·45
2.	27·85	15·82	32·01	23·75	1·52 = 100·45

The results give the formula

$$2\dot{R}^3 \dddot{Si}^2 + 3\dot{R}^2 Ti$$

In the 2nd analysis some titanic acid still remained with the silica.

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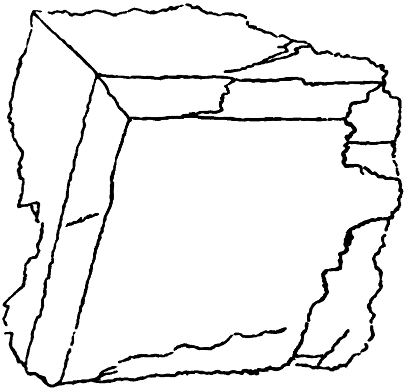
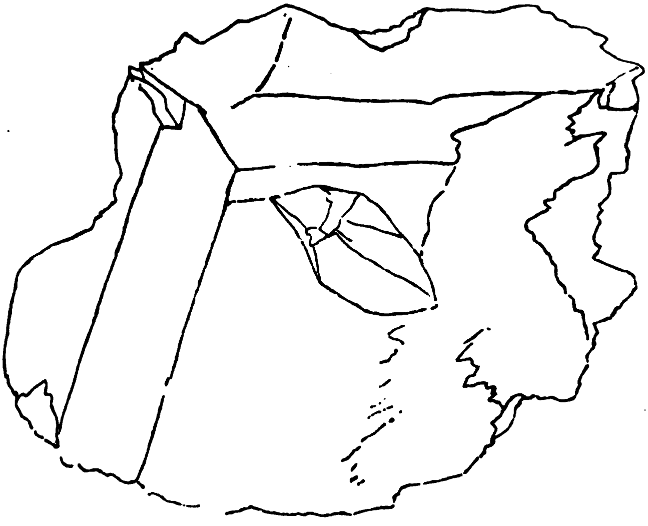
* See pages 223, 228, 230, of this volume.

7. *Large crystals of Sphene.*—The accompanying figures of sphene are by Wm. S. Vaux of Philadelphia, from specimens in his cabinet, obtained at Diana, near Natural Bridge, Lewis Co., N. Y. The color is dark brown. The form is that of the so-called Lederite, which comes from the same locality; the narrow plane is the plane *n*, and the large one below to the right *y*.





8. *On the Ozarkite of Shepard;* by J. D. Dana.—The Ozarkite (this Journal [2], ii, p. 251), after an imperfect examination was pronounced by Prof. Shepard, as probably a silicious hydrate of lime and yttria, with possibly traces of thorina. It has since been examined by J. D. Whitney, who obtained the blowpipe reactions of scolecite. Several specimens from Arkansas have been examined by Mr. G. J. Brush in the Yale Laboratory, New Haven, and found to consist largely of phosphate of lime. They have often the radiated appearance of a zeolite

with acicular crystallizations; but after Mr. Brush's discovery of phosphoric acid, the writer found by means of a glass that the acicular prisms were in fact hexagonal prisms of apatite. Other large prisms were also found in some specimens. The acicular mesotype-like mineral is associated with another of a mealy character and in part sub-lamellar, which may be a zeolite as observed by Whitney.

9. *The Lagoons of Tuscany*, (Bull. Soc. Geol. de France, Dec., 1848, 147.)—The Tuscan Lagoons are, properly speaking, natural depressions of the soil ordinarily filled with water from which hot vapors are ejected. They are situated within a space of ten or twelve miles, lying between 28° 27′ and 28° 40′ of longitude, and between 43° 10′ and 43° 15′ of latitude. The principal lagoons are those of Monte Cerboli, of Castel Nuovo in the valley of Cecina, those of Sasso, of Monte Rotondo, of the Lago del Edifizio, of Lustignano and of Serrazzano in the valley of Cornia. The ancients were acquainted with the Tuscan lagoons, and the name of Mount Cerberus accords well with the poetical and mythological ideas of the early people of Italy.

Even as late as the 18th century the lagoons were regarded only as a supernatural wonder which excited astonishment rather than courted investigation. Under the Grand Duke Leopold 1st, the chemist Hœfer discovered by analysis, that they contained boracic acid. This discovery, followed by farther explorations, has bestowed upon the lagoons an unrivalled industrial importance, and has brought into the countries possessing them an activity contrasting strikingly with the miserable state in which they before languished. It is a curious fact in their history that before the discovery of this acid, the fetid odor developed by the sulphuretted hydrogen gas,—the certain death which met the man who fell into the scalding baths,—the disruptions of the ground occasioned by the appearance of new *Soffioni*,—and above all the superstitious terror with regard to them, had made the people consider the lagoons as a scourge from which they sought deliverance by public prayers; but now if by any cause the *Fumacchi*, the source of common prosperity, should become extinguished, they would not fail to seek from heaven a restoration of this scourge, which in the skillful hands of M. Larderel, has become, to quote M. Bowring, a source perhaps of greater riches than the mines of Peru, or of Mexico, and certainly more reliable. After the discovery of Hœfer, Paul Mascagni, a noted chemist, had the first idea of procuring from the lagoons boracic acid like that of China, and of thus restoring to Europe the tribute that she had paid to Asia. But the attempt was not at first profitable, as the waters contain in solution at the moment of their escape from the earth, only an insignificant quantity of boracic acid. Another chemist having observed that a part of the acid was thrown beyond the lagoon, by the violence of the vapors, and that it was scattered on the margins of the craters, and moreover being confident that the waters were capable of dissolving a greater quantity of acid, endeavored to find means of saturating them by constructing upon the declivities of the country artificial lakes fed by the streams from the mountain. The vapors which issue from these lakes keep their waters constantly at a boiling temperature. After impregnation for twenty or thirty hours by the vapors of the highest lake, they draw off the waters into the second lake to submit them to a new impregnation. From thence they are drawn into a third, and so on till they reach the receptacle at the lowest point. In their passage across six or eight lakes, they are charged with half per cent. of boracic acid. They are then led into the reservoir from which they are conducted into lead reservoirs for evaporation, to produce concentration; and to hasten that operation, the happy idea was proposed of substituting for the combustibles sometimes used, and which were enormously expensive, the direct application of the heat of the Soffioni. This improvement decided the success of the enterprise. It is surprising that it was introduced at so late a day, since this method was not new and had been long practiced at the solfatara of Pozzuoli in extracting alum from the earth that contains it. In the lagoons, the hot vapors for carrying on the evaporation are taken at their origin and carried across by lead pipes or by subterranean conduits below the boilers. Thus the fabrication is exceedingly simple, the locality itself furnishing the means of carrying it on. A single discharge of the vapors is sufficient to throw into ebullition, almost immediately, 20 or 30 cauldrons of a capacity of 20 barrels, which may be estimated at 84,000 pounds of liquid impregnated with boracic acid. Before allowing the vapors to escape, they direct them under the ovens in order to free the acid from its hygrometric moisture. Of late the somewhat complex system of boilers and coolers has been simplified by substituting rectangular tables of lead of 20 or 30 metres, divided at small intervals by transverse parallel divisions, but whose height is never raised above that of the edges. These tables have an inclination of two to three degrees. The water of the last lagoon is introduced upon the upper side, in small quantities. The hot vapors for evaporating are conducted in such a manner that they act upon the lower surface. The liquid after having filled the first compartment is diffused very gradually into the second, then into the third, and so successively to the last, where it reaches such a state of concentration that it deposits the crystallized acid; the workmen remove it immediately by means of wooden scrapers. This mode of gradual concentration is very ingenious, and requires so few hands that it may almost be said that the acid is obtained without expense. From 1818 to 1845 the quantity of acid manufactured was 33,349,097 Tuscan pounds. From 1839 to 1845 the mean quantity has been two millions and a half of pounds.

Thus in estimating the product at 7,500 pounds per day; the quantity of saturated water upon which they operate daily is 1,500,000 lbs. daily, and annually 547,500,000 lbs.

This labor brings to Tuscany 12 millions of pounds (10 millions of francs), and it is surprising that it should have remained unproductive during so many ages, and that it should have been reserved for the skill of M. Larderel, now Count of Monte Cerboli, and before 1818 a simple wandering merchant, entirely unacquainted with scientific researches, to discover the fugitive vapors and render them a source of inexhaustible wealth.

The violence with which the burning vapors escape gives rise to muddy explosions, when a lake has been drained by turning its waters into another lake. The mud is then thrown out, as solid matters are ejected from volcanos, and there forms in the bottom of the lake a crowd of those little cones of eruption whose activity and play recall exactly under another form the *hornitos* of Malpays. Their temperature varies from 120° to 145° centigrade, and the clouds which they form above the lagoons constitute true natural barometers, whose greater or less density rarely disappoints the predictions that they announce.

While in an industrial point of view, the lagoons occupy the first rank among the natural products of Tuscany, they place new resources at the disposition of science, permitting the investigation of various geological phenomena, even under the direction of the will of the experimenter. The metamorphic gypsum which we have seen produced at Pereta under the influence of sulphuretted hydrogen vapors, is formed at the lagoons which, like those of *Monte Cerboli* and of *Castel Nuovo*, are made to cross argillaceous limestone beds; and with such abundance that their formation may be fully tested. Action also takes place at the same time upon the walls of fractures and the fissures of the soil which open a passage to the subterranean vapors. Thence it extends gradually into the interior of the masses, and it ends by gypsifying whole circles whose radius is generally that of the lagoons themselves. Pure limestones are converted into a lamellar sulphate of lime, but of a loose texture and free of cellules. This structure is probably due to the expansion they undergo from the addition of new materials, and perhaps also by the passage of the gas at the moment of the crystallization of the salt. The calcareous formations below the argillaceous, preserve after their transformation their primitive position, and they present an alternation of gypseous beds, and of argillaceous beds which the acid has freed from the soluble bases. When this influence is exerted in the direction of the thickness of the strata, it is very common to see towards the limits where the metamorphic influence ceases, a mass of rock strikingly calcareous at one of its extremities, terminating at the other extremity in a gypsum which the inhabitants use for buildings. The resemblance to the gypsum beds, occurring in the midst of the secondary formations, is exhibited even in the reddish tint with which oxydation marks the associate clays of the alberèse. But a peculiarity which has given me the solution of a problem which had embarrassed me thus far, deserves mention; for we have reproduced here certain phenomena of which the enormous deposits of the Provençal Alps present many examples. I had noticed at Roquevaire and at Digne, irregular argillaceous incrustations in which are found entangled without order, angular fragments of sulphate of lime of various sizes. In admitting the transformation of the jurassic limestone of these countries posterior to its consolidation under the influence of the acid vapors, it was difficult to explain the mode of formation of these breccias and the manner in which these fragments were introduced. In all these cases, they seemed to indicate an overflow of waters, but the theory opposes the intervention of waters for the accomplishment of the facts relative to the conversion of the limestone, or it leaves in doubt the part which they must have acted. But, observe what is apparent at the lagoons of Monte Cerboli and of Castel Nuovo. At the same time that the limestone is changed into gypsum, by the contact of sulphurous agents, the fragments of alberèse which waters had brought down from heights above to the midst of the miry and boiling lakes, are thus changed into sulphate of lime and constitute, with the clays in which they sink, brecciated argillo-gypseous beds without stratification. That this fact should be equally apparent in the ancient beds under analogous circumstances, is at least what might be inferred from the examination of that which passes in the lagoons. We should also observe the analogous positions of the *boracite* of Luneburg, which is found in crystals disseminated in gypsum intercalated in the midst of a cretaceous bed, and the boracic acid and borates of the Tuscan lagoons.

These different facts well confirmed, establish in my view an intimate resemblance between the gypsum of the lagoons and the abnormal gypsum beds of secondary regions.

If the silicification of the Macigno which we have noticed in the neighborhood of the solfatara of Pereta should appear an exaggerated application of the theory brought forward, the verification of it may be traced in the lagoons of *Sasso* where the solution of the silex of the freestone and its redeposition are manifest in all places where circumstances allow of this double transformation. The Fumacchi of Sasso rise, to the south of the establishments, from beneath a vast mantle of fine grained freestone, over which passes the mountain road connecting the valley of the Cornia with the Province of Sienna. At intervals the road is interrupted by isolated boiling pools or shallow cavities, which exert a metamorphic action upon the region which they traverse. The first evidence of alteration is apparent in the color of the rock which from blackish gray becomes white. It is cracked in all directions. The vapors follow quickly these lines of separation, attack the silica of the macigno, dissolving it out, and immediately depositing it under a gelatinous form. The gelatinous mass becomes opaque in the air and assumes the resin-like appearance peculiar to hydrated silica. In connection with this we observe imbedded in a silicious cement, nuclei of a white micaceous sandstone unaltered at centre, causing a breccia appearance. This kind of breccia is finally, by the complete solution of the nuclei, converted into a grayish rock entirely silicious, which resounds under the hammer like clink-stone, and resembles exactly by its aspect and its roughness of touch, porcelain biscuit. Sometimes the solution is more rapid, and then the rock is formed of an agglutination of little grains analogous to those of an ancient quartz rock and possessing its tenacity and hardness. Examined with a glass, each grain is composed of an independent particle or driblet of hydrated silica, and they seem to have collected as viscous tears, such as would have adhered together in hardening. Breislak observed at the solfatara of Pozzuoli fragments of decomposed lava bound together by a silicious substance almost vitreous; but in the lagoon of Sasso the solution and permanent regeneration of silica effected at the expense of the macigno, are carried on upon a vast scale and over a space of great extent.

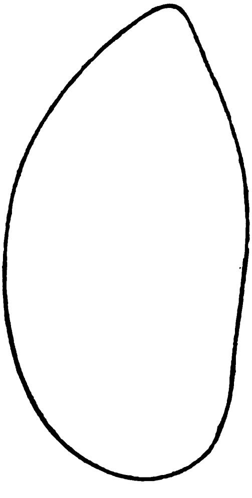
10. *On the Great Diamond in the possession of the Nizam;* by HENRY PIDDINGTON, Curator, Museum Economic Geology.—At the November meeting of the Asiatic Society, Captain Fitzgerald, B.A., presented for the inspection of the Society a model in lead of this remarkable stone, and gave a brief note of its history, which will be found in my report for that month. He has since favored me with a more detailed one, which is as follows:—

Note by Captain Fitzgerald, Bengal Artillery, attached to the Nizam's Service, on the Nizam's Diamond—*1st December*, 1847.—"About twelve or fourteen years ago a large diamond was found in the Nizam's country under circumstances of rather a curious nature. The model now shown is the model of a part only, a piece having been chipped off, which, after passing through many hands, was purchased by a native banker for 70,000 rupees.

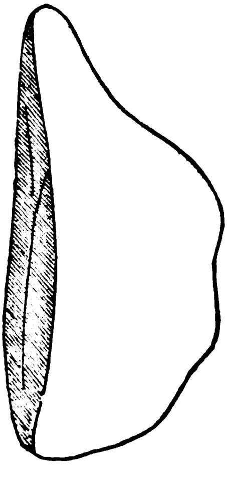
The larger piece, as represented by the model, is in the possession of his highness the Nizam, and at the time of discovery was exhibited to many European gentlemen.

The manner in which this diamond was originally found, may be considered interesting. It was first seen in the hands of a native child, who was playing with it, of course ignorant of its value. On *eight* annas being offered for what the poor people considered as a mere stone, their suspicion was excited, which led ultimately to the discovery of the bright stone being a real diamond.

Its form and size is shown below. This stone, hitherto unknown, may now be classed among the larger description of diamonds which we read of, but seldom see.



Base.



Side view.

The size of the stone exactly taken by callipers, from the leaden model, is as follows:—

	Inches.
Length, ...	2·48
Greatest breadth, ...	1·35
Average thickness, ...	0·92

I have had now exact models cast in glass from the leaden one exhibited at the meeting, and I find that

	Grains.
Their absolute weight is, ...	1164·50
Their specific gravity, ...	3·70

Now according to various authorities we have for the specific gravity of the diamond,

Ure,	3·53
Brewster, colorless,	3·52
orange,	3·55
Jameson, twelve authorities, mean,	3·52
Mean,	3·52

And hence assuming our model to be exact, (and it is very nearly so,) we have by a simple proportion not quite 1108 grains for the actual weight of the Nizam's diamond.

This is equal to 277 carats of weight of the rough diamond, and as the rough stones are usually taken to give but one half of their weight when cut and polished, it would allow 138½ carats, or a weight between the Pitt (or Regent) diamond (136¾ carats), and that of the Grand Duke of Tuscany (139 carats), for it in its present condition; and if we take it that one-eighth of what it would be when polished was taken off with the splinter sold to the native, as related by Captain Fitzgerald, we shall then have 155¾ carats for the possible weight of it, if it had been cut and polished entire; which would then place it as to weight between the Tuscan and the great Russian diamond of 195 carats, which last is well known to be an Indian stone.

We are not informed if this stone is considered likely to be one of pure water, which can only be ascertained by polishing it, though we know that the natives of India, and particularly of the Deccan, are too good judges of diamonds to mistake a topaz for one, and it is stated that 70,000 rupees have been paid for the fragment. It therefore certainly adds one extraordinary fact more to the history of this most wonderful of the gems."

11. *An account of the Strata and Organic Remains exposed in the Cuttings of the Railway from the Great Western line near Corsham, through Trowbridge to Westbury in Wiltshire;* by REGINALD NEVILLE MANTELL, Esq., Civil Engineer, (Proceedings of the Geological Society of London, Feb. 27, Sir C. Lyell, President, in the Chair.)—This line in the distance of fifteen miles passes through the usual series of the subdivisions of the oolite formation of that part of England. Numerous displacements of the strata occur, and in some parts thick beds of alluvial drift are superimposed on the regular deposits, and contain water-worn fragments of rocks and fossils from various formations. Near Westbury an extensive accumulation of bones of elephants and other large herbivorous mammalia was cut through; the quantity of these remains being so great, that they were employed to form an embankment. The immense number of fossil shells exposed in some of the areas, laid bare by the works, was surprising; the whole surface being thickly spread with Ammonites and other Cephalopoda, and osselets of Belemnoteuthis and Belemnites, mixed with shells of Rostellaria, Murex, Terebratula, Turritella, &c., deep sea and littoral mollusca being promiscuously intermingled. Some of the finest examples of Belemnites and Belemnoteuthis hitherto known, were found in these deposits, and have been described by Dr. G. A. Mantell [the author's

father] in the Philosophical Transactions. With these remains, were found teeth and bones of fishes and of four or five genera of reptiles. In the strata of Oxford clay lignite occurs abundantly, and in some places very large trunks and branches of coniferous trees, the wood retaining its structure and tenacity. The whole deposit resembled a mud-bank of a deep sea to which trees and other terrestrial plants, and littoral shells, had been drifted and mixed up with the relics of the mollusca of the profound depths of the ocean; constituting an interesting example of what M. Constant Prevost has aptly termed a fluvio-oceanic formation. The paper was illustrated by drawings and sections, and a splendid series of the fossils collected and arranged by the author: a table of all the genera and species by John Morris, Esq., was appended.

12. *Notice of the Remains of the Dinornis and other Birds, and of Fossil and Rock specimens recently collected by Walter Mantell, Esq., from the Middle Island of New Zealand;* by G. A. Mantell, Esq., LL.D., F.R.S., &c., (Ibid.)—This memoir consisted, 1st, of a descriptive account of the country explored by Mr. Walter Mantell as Government Commissioner for the settlement of native claims on the east coast of the Middle Island, extending from northwest of Bank's Peninsula to Otago, a distance of about two hundred and sixty miles. 2dly, a general notice of the rocks, minerals and fossils; and 3dly, a summary of the facts brought to light in the course of the survey: forming the most interesting sketch hitherto made of the geology of that part of the colony. The rock specimens consisted of between 200 and 300 examples; principally of plutonic, metamorphic, and igneous substances. The foundation rocks of the country appear to be metamorphic schists, these are traversed by dykes of basalt, amygdaloids, &c. Obsidian, vesicular lava, and volcanic grits, in many places flank the sides of the great mountain chains which reach above the line of perpetual snow; and along the base of the range and over the adjacent plains are thick deposits of conglomerates and rich alluvial loam. Along the coast towards the south unaltered sedimentary strata appear. These belong to three distinct groups. The most ancient is the Ototara limestone which abounds in Terebratula, Echini, shark's teeth, &c., like certain European cretaceous beds; and the chief mass is composed of microscopic foraminiferous shells precisely similar to the white chalk of England; even the soft parts of the bodies of these minute animals are in many instances preserved. The deposit next in age is a blue upper tertiary clay full of marine shells of species still existing in the South Pacific Ocean.

Lastly, a ferruginous sandy grit with shells of recent marine species superimposed on the blue clay. Over the whole are spread, unconformably, layers of gravel and loam. Low hills of marly sand occur along the shores of the North Island, apparently a modern drift; this sand is wholly made up of the frustrules of Diatomacea. Of the fossil remains of birds the present collection contains above five hundred specimens referable to various species of Dinornis and allied genera; and to species of *albatross*, *penguin*, *water-hen*, *nestor*, *apteryx;* with portions of egg-shells of three different types. With the above were associated bones of a species of dog, and of two species of seal. The bones from the North Island, like those previously collected by Mr.

W. Mantell, and now in the British Museum, were from the titaniferous iron-sand near the mouth of the river Waingongoro. Those from *Waikouaiti* in the Middle Island, were imbedded in a morass of small extent, and which is exposed only at low water. This swamp is composed of vegetable fibres, sand and animal matter; it seems to have been originally a morass in which the *Phormium tenax*, or New Zealand flax, grew luxuriantly. The bones are literally tanned; and so well preserved as to appear as fresh as if recent. Among the specimens are crania and mandibles, and bones of the most colossal size. The most extraordinary relics are the entire series of bones (twenty-six in number) of the feet and shanks of the same individual Dinornis robustus, found standing erect, the one about a yard in advance of the other, as if the bird had been mired, and unable to extricate itself had perished on the spot. They were dug up and carefully numbered seriatim, and are now articulated like a recent skeleton. This is the only known instance of the bones of the foot and tarsus in natural connection, and consequently the first certain example of the structure of the feet of the colossal birds of New Zealand. There are no clear indications of this bird having had a hinder toe, as in the smaller species of Palapteryx in which the articulation for a posterior toe is strongly marked. The foot when recent must have been sixteen inches long and eighteen inches wide; the height of the bird to which they belonged, was about ten feet. The author in a highly interesting summary, suggests that these bone deposits, though geologically modern, are of high antiquity in relation to the human inhabitants of New Zealand; and considers it probable that these stupendous birds formerly ranged over a vast continent, now submerged, and of which the islands of the Pacific are the culminating points. Although there seems little doubt that like the Dodo and Solitaire of the Mauritius, and the gigantic elk of Ireland, the last of the Moas was exterminated by human agency, yet it is probable that a change in physical conditions, had prepared for their final annihilation. Of the organic law which determines the extinction of a race of highly organized beings, and whose effects through innumerable ages palæontology has in part disclosed, we are as utterly ignorant as of that which governs the first appearance of the minutest living organisms the powers of the microscope enable us to descry: both are veiled in inscrutable mystery; the results only are within the scope of our finite comprehension.

III. ZOOLOGY.

1. *Supplementary Observations on the Structure of the Belemnite and Belemnoteuthis;* by GIDEON ALGERNON MANTELL, Esq., LL.D., F.R.S., Vice President of the Geological Society, &c.—(Proc. Royal Society, February 14, 1850.)—In this communication the author describes his recent investigations on the structure of the two genera of fossil Cephalopoda, whose remains occur so abundantly in the Oxford clay of Wiltshire, namely, the Belemnite and Belemnoteuthis, as supplementary to his memoir on the same subject, published in the Phil. Trans., 1848. In that paper evidence was adduced to show the correctness of the opinion of the late Mr. Channing Pierce, as to the generic distinction of these two extinct forms of Cephalopoda.

As however several eminent naturalists have expressed doubts as to some of the opinions advanced by the author in his former memoir, figures and descriptions are given in the present notice, of beautiful and instructive specimens lately discovered in Wiltshire, and which he conceives establish his previous conclusions. Dr. Mantell states as the result of his examination of several hundred examples, that our actual knowledge of the organization of the animal of the Belemnite is at present limited to the following parts, viz.—

(1.) An external *Capsule* or *periostricum* which invested the osselet or sepiostaire, and extending upwards, constituted the external sheath of the receptacle.

(2.) The *Osselet*, characterized by its fibrous radiated structure, terminating distally in a solid rostrum or guard, having an alveolus, or conical hollow, to receive the apical portion of the chambered phragmocone; and expanding proximally, into a thin cup, which became confluent with the capsule, and formed the receptacle for the viscera.

(3.) The *Phragmocone*, or chambered, siphunculated, internal shell; the apex of which occupied the alveolus of the guard, and the upper part constituted a capacious chamber, from the basilar margin of which proceeded two long, flat, testaceous processes. These structures comprise all that are at present known of the animal to which the fossil commonly called "*The Belemnite*," belonged.

Of the *Belemnoteuthis* (the fossil cephalopod which Prof. Owen regards as identical with the Belemnite) many examples of the body with eight uncinated arms, and a pair of long tentacula, having an ink-bag and pallial fins, have been discovered. The osselet of this animal, like that of the Belemnite, *has a fibro-radiated structure*, investing a conical chambered shell; this organ, for reasons fully detailed in the memoir, the author affirms could never have been contained within the alveolus of a Belemnite; the soft parts of the animal of the Belemnite are therefore wholly unknown.

Many beautiful specimens of Belemnites and Belemnoteuthis were exhibited by Dr. Mantell to the Society, in proof of the statements contained in the memoir.

2. *On the Pelorosaurus; an undescribed gigantic terrestrial reptile, whose remains are associated with those of the Iguanodon and other Saurians, in the Strata of Tilgate Forest;* by GIDEON ALGERNON MANTELL, Esq., LL.D., F.R.S., Vice President of the Geological Society, &c. (Ib.)—The author had for a long while entertained the idea, that among the remains of colossal reptiles obtained from the Wealden strata, there were indications of several genera of terrestrial saurians, besides those established by himself and other geologists. The recent discovery of an enormous arm-bone, or humerus, of an undescribed reptile of the crocodilian type, in a quarry of Tilgate Forest in Sussex, where Dr. Mantell had many years since collected numerous teeth and bones of the Iguanodon, Hylæosaurus, &c., and some remarkable vertebræ not referable to known genera, induced him to embody in the present communication the facts which his late researches have brought to light.

The humerus above mentioned was found imbedded in sandstone, by Mr. Peter Fuller of Lewes, at about twenty feet below the surface; it presents the usual mineralized condition of the fossil bones from the arenaceous strata of the Wealden. It is four and a half feet in length, and the circumference of its distal extremity is thirty-two inches! It has a medullary cavity three inches in diameter, which at once separates it from the Cetiosaurus and other supposed marine saurians, while its form and proportions distinguish it from the humerus of the Iguanodon, Hylæosaurus, Megalosaurus. It approaches most nearly to the Crocodilians, but possesses characters distinct from any known fossil genus. Its internal structure is beautifully preserved, the Haversian canals and bone-cells being as distinct as in recent bones. Its size is stupendous, far exceeding that of the corresponding bone even of the gigantic Iguanodon; the name of *Pelorosaurus* (from *πελωρ*, monster) is therefore proposed for the genus, with the specific term *Conybeari*, in honor of the palæontological labors of the present Dean of Llandaff, the Rev. W. D. Conybeare.

No bones have been found in such contiguity with this humerus, as to render it certain that they belonged to the same gigantic reptile; but several very large caudal verterbræ of peculiar characters, collected from the same quarry, are probably referable to the Pelorosaurus; these, together with some distal caudals of the same type, are figured and described by the author.

Certain femora and other bones from the oolite of Oxfordshire, in the collection of the Dean of Westminster at Oxford, are mentioned as possessing characters more allied to those of the Pelorosaurus, or to some unknown terrestrial saurian, than to the Cetiosaurus, with which they have been confounded.

As to the magnitude of the animal to which the humerus belonged, Dr. Mantell, while disclaiming the idea of arriving at any certain conclusions from a single bone, stated that in a Gavial eighteen feet long, the humerus is one foot in length; *i. e.* one-eighteenth part of the length of the animal, from the end of the muzzle to the tip of the tail. According to these admeasurements the *Pelorosaurus* would be eighty-one feet long, and its body twenty feet in circumference. Even if we assumed the length and probable number of the vertebræ as the scale, although we should have a reptile of relatively abbreviated proportions, yet in this case, the original creature would surpass in magnitude the most collossal of reptilian forms.

In conclusion, Dr. Mantell comments on the probable physical conditions of the countries inhabited by the terrestrial reptiles of the secondary ages of geology. The highly organized land saurians appear to have occupied the same position in those ancient faunas, as the large mammalia in those of modern times. The trees and plants whose remains are associated with the fossil bones, manifest, by their close affinity to living types, that the islands or continents on which they grew, possessed as pure an atmosphere, as high a temperature, and as unclouded skies, as those of our tropical climes. There are therefore no legitimate grounds for the hypothesis in which some physiologists have indulged, that during the "*Age of Reptiles*" the earth was in the state of a half-finished planet, and its atmosphere too heavy, from an excess of carbon, for the respiration of warm-blooded animals. Such an opinion can only have originated from a partial view of all the phenomena which these problems embrace; for there is as great a discrepancy between the existing faunas of different readings, as in the extinct groups of animals and plants which geological researches have revealed. The memoir was illustrated by numerous drawings, and the gigantic humerus of the Pelorosaurus and other bones were placed before the Society.

3. *On Entophytes;* by Dr. Leidy, (Proc. Acad. Nat. Sci., Philad., Feb., 1850, v, p. 8.)—Dr Leidy presented to the examination of the Society a colored and several other drawings of what he termed an entophytic forest, taken from a portion of the mucous membrane of the ventriculus of Passalus cornutus. He remarked that at least six species of entophyta were found growing upon the mucous membrane of the ventriculus of P. cornutus, which were often present in great quantity, frequently some thousands, and which from their number, polymorphous appearance of several species, and attachment to various appendages of the mucous membrane, resembled very strikingly a miniature Brazilian forest, which was heightened in some degree by the existence of a nematoid worm, which recalled to mind the idea of one of the serpents of such a forest.

A somewhat similar drawing he exhibited, taken from the small intestine of Julus marginatus.

Other drawings were also presented. Dr. L. stated that among his collection of Julides, he had a number of times observed individuals to become dull in color, and almost motionless, which phenomena were followed by the death of the animal. It occurred to him that, in such a state, there might be exhibited some change in the character of its entophyta, as usually found in the active condition of the animal. Upon removing the intestine of an individual which had just died, he noticed that the entozoa which usually occupied the small intestine, had passed into the rectum, and upon the surface of the mucous membrane of the former, was developed a new plant. This is an oblate spheroidal body, white in color, translucent, embossed upon the surface, and presenting, when viewed by transmitted light, some resemblance to a minute bleached shell of an Echinus; by reflected light, it resembled a minute, white Lycoperdon. This plant was strewed all over the mucous membrane, but grew in greatest quantity along the course of filaments of Enterobrus, which appeared attached to the mucous membrane throughout their length by it. When compressed it opened, and spread into several leaf-like segments, and exuded a clear fluid with faint granules. He thought that probably this plant might be another stage in the existence of Enterobrus, for in the large number of individuals of Julus which he had examined, upward of 130, although he had observed the development of Enterobrus from spore-like bodies, even to the formation of what he supposed to be the sporangia, yet he had never been able to detect the formation of spores, and when he saw this new plant enveloping the Enterobrus filaments, he suspected that there might be a phenomenon here presented analogous to the alternation of generation in certain animals, but had not yet satified himself that such was the case.

He also stated that he had discovered a fourth species of Enterobrus in Polydesmus virginiensis, and another entophyte analogous to Enterobrus growing in Polydesmus granulatus. The latter differs from Enterobrus in having numerous globular cells at the free extremity of the principal cell. He adverted to the several theories of cell formation, and said that in the last mentioned plant, in the development of the globular terminal cells, the division of the permanent cell wall followed the division of the cell contents. In conclusion, he observed, that these matters would be more fully treated of hereafter, in a memoir which he was preparing on the subject.

4. *On Infusoria on the Teeth;* by Dr. H. I. BOWDITCH, (Proc. Amer. Acad. of Arts and Sciences, Boston, Dec., 1849, p. 183.)—Dr. H. I. Bowditch gave the result of the microscopic examination of the accumulations on the teeth of healthy persons, near the gums, in forty-nine individuals, most of whom were very particular in their care of the teeth. Animalcules and vegetable products were found in every instance except two. In those cases the brush was used three times a day, and a thread was passed between the teeth daily. Windsor soap was also used by one of these two persons, with the brush. Dr. Bowditch had tried the effects of various substances in destroying the animalcules, and especially of tobacco, by which they seemed to be in no wise incommoded. Soap-suds and the chlorine tooth-wash invariably destroy them.

IV. ASTRONOMY.

1. *New Comet.*—(Jour. of Com.)—Rev. Mr. JENKINS, of Georgetown College, writes that on his way to Rio Janeiro, Nov. 28, 1849, he saw distinctly a comet to westward, nearly in the track of the sun, and about 14 degrees above the horizon (hour not mentioned); the nucleus being very distinct, and about as large in appearance as Mars, the tail curved and pointing southward, quite bright and nearly a degree in length, as seen by the naked eye.

2. *Expected return of the great Comet of* 1556.—This comet is generally supposed to be identical with that of 1264, and if so, its period must be about 292 years. Leaving out of view any consideration of the effect of planetary action, the return of this comet might have been expected at any time since February, 1848. Although watch has been constantly kept since that period, the comet has not been detected. But its return is not yet to be despaired of. Mr. J. R. Hind, of London, states in a letter to the Editor of the *London Times*, dated March 7, 1850, that Mr. J. T. Barber of Etwell, has computed the effect of the perturbations due chiefly to Jupiter's attraction during the last revolution. Mr. B. finds that "between the years 1556 and 1592, the united attraction of Jupiter and Saturn would diminish the period 263 days, but that between 1592 and 1806, it would be increased by the action of Jupiter alone no less than 751 days, so that a retardation of 488 days must take place. How much longer Saturn, Uranus and Neptune may detain it beyond this time, we do not at present know." Mr. Hind considers it important that search for the comet should be continued until the close of 1851, and that on the supposition that it is within four or five months of its return to perihelion, the region of the heavens about the constellation Hydra should at this time be particularly examined.

V. MISCELLANEOUS INTELLIGENCE.

1. *On the Gradual Production of Luminous Impressions on the Eye, and other phenomena of Vision;* by WILLIAM SWAN, F.R.S.E. (Proc. Roy. Soc. Edinb., 1849, ii, 230.)—The object of this communication was to ascertain the relation between the apparent brightness of a light, and the time during which it acts on the eye. In order to examine the intensity of luminous impressions of short duration, the author made use of discs, having sectors of known angles cut out of their circumferences, which were made to revolve at known velocities between the eye and a luminous object. In this manner, the object is seen at each revolution of the disc for a short interval of time, of which the duration is easily ascertained. An instrument termed a Selaometer (from σελας, *brightness*), to indicate its use as a measure of the intensity of luminous impressions, was devised for the purpose of comparing the brightness of the flashes caused by the revolution of the disc, with a light of known intensity. This instrument consists of two screens, placed so as to face each other, having each a circular aperture of the same diameter, to which is fitted a piece of obscured glass. A disc, having a sector of a known angle, revolves in fornt of one of these screens, so that the aperture in it is visible at each revolution of the disc throughout the sector. The apertures are illuminated by gas flames behind them, which admit of having their distances from the screens varied, so as to increase or diminish the illumination of the apertures. A rectangular prism of glass is placed half way between the apertures, with its faces inclined at angles of 45° to the line joining their centres; so that they are seen in apparent contact by reflection from the faces of the prism, and their relative brightness can thus be compared with great nicety. The light behind the revolving disc is kept at a constant distance from the screen during an experiment; and, before causing the disc to revolve, the apertures are made equally bright by varying the distance of the other light from its screen. When the disc is put in motion, the apparent brightness of the aperture behind it is instantly diminished; and the equality of the apparent brightness of the apertures in the screens is restored, by increasing the distance of the light from the other screen. The ratio of the brightness of the impression produced by the light during the revolution of the disc, to the brightness of its impression, when seen by uninterrupted vision, is that of the squares of the distances of the other light from the aperture in its screen.

The following are the principal results obtained by means of this apparatus:—

(1.) When the eye receives, from a light of common intensity, a succession of flashes of equal duration, which succeed each other so rapidly as to produce a uniform impression, this impression will also have a constant intensity, provided the number of flashes in a given time varies inversely with the duration of each flash.

(2.) The brightness of the impression produced by flashes of light of a given intensity, which succeed each other so rapidly as to produce a uniform impression on the eye, is proportional to the number of flashes in a given time.

(3.) When light of a given intensity acts on the eye for a short space of time, the brightness of the luminous impression on the retina is exactly proportional to the time during which the light continues to act. This law has been proved to be true for impressions lasting from $\frac{1}{18432}$ to $\frac{1}{24}$ of a second. The intensity of the impression produced by light which acts on the eye for $\frac{1}{100}$ of a second, is almost exactly $\frac{1}{10}$ of the brightness of the light when seen by uninterrupted vision; and it is also ascertained that light requires about the tenth part of a second to produce its full effect on the eye.

(4.) It is found that lights of different intensity act on the eye with equal rapidity, so that even the light of the sun produces an impression with no greater rapidity than that of a common gas flame.

(5.) Rays of different refrangibility act on the eye with equal rapidity.

(6.) Since Professor Wheatstone's experiments have proved that the light of the electric spark of high tension continues for less than the millionth part of a second, and it has been shewn that the brightness of the impression, produced by light on the eye, increases in the arithmetical proportion of the time during which it continues to act on the retina, it follows that the apparent brightness of the electric spark is only $\frac{1}{100000}$ of what it would become if the duration of the spark could be prolonged to $\frac{1}{10}$th of a second. From the great apparent brilliancy of the nearly instantaneous electric spark of high tension, when compared with the sensibly continuous light of Voltaic electricity, it is inferred that the brightness of electrical light increases with the tension of the electricity.

2. *Foster's Geological Chart.*—The following announcement has been received for publication in this Journal. It affords us pleasure to know that the Chart alluded to has not the sanction of Prof. Mather's name.

Jackson C. H., Ohio, March 28th, 1850.

To the Editors of the American Journal of Science.

Gentlemen,—I received a few days since the March No. of the Am. Jour. of Science, in which is a notice of Foster's Geological Chart, (vide p. 309, vol ix, new series,) saying "A revised copy, as now ready for publication, having the signatures of Professors E. Emmons and W. W. Mather, has been shown us by the author."

My name on that Chart is a forgery. I have never seen the Chart, have never authorized my name to be put on it, and pronounce the attempt to palm off that production under my signature or recommendation, a base imposition on the public, and a still baser imposition on me.

[Signed] W. W. Mather.

3. *Lefroy on the Application of Photography to the Self-registration of Magnetical and Meteorological Instruments,* (see page 319.)—Mr. Lefroy has sent us the following account of his method of treating his mirrors when tarnished.—The mirror will probably be found in course of time, to get tarnished and to require cleaning, this may be done with soft leather, from which all the dust has been beaten out, and which has been well washed in soap and water, and dried before use. If a turning lathe is at hand, a convex buff, fitting the mirror, and well covered with two or three thicknesses of leather, may be centered on it, and the mirror held against it in a support of some kind, while it is made to revolve, but

the least application of polishing powders, however fine, will endanger an alteration in the form of the mirror, and destroy the sharpness of the focus capable of being produced by it. The greatest care must be taken to keep the leather clean and dry.

4. *On the Cause of the Diurnal Variations of the Magnetic Needle;* by W. H. Barlow, Esq., M.I.C.E.—(Phil. Mag., [3], xxxiv, 344, from a letter addressed by Mr. Barlow to the Editors of the Phil. Mag.)—In the number of your Journal for April, an extract from a letter from M. de la Rive to M. Arago is published, in which the author attributes the diurnal variations of the magnetic needle and the auroræ boreales to the effect of electric currents at the surface of the earth and in the atmosphere.

In the confirmation of this theory mention is made of a remarkable effect observed by M. Matteucci in the apparatus of the electric telegraph between Ravenna and Pisa during the magnificent aurora on the 17th of last November; and the author concludes by observing that "it would be highly interesting and important to profit by those telegraph wires, which are found to have a direction more or less approaching to that of the declination needle, in order to make with them, when they are not in use for ordinary purposes, some observations which would enable us to demonstrate and to measure the electric currents which probably traverse them."

My object in addressing you is to state, that in the early part of 1847, I was led to undertake extensive observations on this subject, in consequence of the peculiar disturbances occasionally visible on the telegraph instruments of the Midland Railway (on which line the telegraph was erected under my superintendence as the company's engineer).

These disturbances were at first attributed to atmospheric electricity passing to the earth by means of the wires; but from certain effects observed, I was led to infer that they were due to other causes; and in order to explain these effects, it is necessary to state that the Midland system of telegraphs consists of four principal lines centering in Derby, as follows:—

1st. From Derby northwards to Leeds.
2nd. From Derby northeast to Lincoln.
3rd. From Derby southwards to Rugby.
4th. From Derby southwest to Birmingham.

The disturbances on these four telegraphs were observed to occur simultaneously, with rare exceptions; and the direction of the current in the two telegraphs proceeding northerly and northeasterly was always contrary to those proceeding southerly and southwesterly; that is to say, when the deflection was such as to indicate that the current was towards Derby on the first two, it was from Derby on the last two; and when it changed in one, it changed in all. It was also observed that on the 19th of March 1847, there was an unusual degree of disturbance during the presence of auroræ boreales.

As these effects could not be attributed to the transit of ordinary atmospheric electricity along the wires to the earth, I determined to make a set of experiments on the subject.

Having obtained delicate galvanometers, I first ascertained that currents are at all times perceptible in the telegraph wires to a greater or less extent when the galvanometer is applied on a sufficient length of wire, and between two earth connections; but that wires having no earth connection, or only one, exhibited no currents.

I also found by simultaneous observations on two galvanometers, applied one at each extremity of a wire forty-one miles long, that the changes of force and direction of the currents were simultaneous at both ends; the current passing direct from one earth connection to the other.

But the most interesting fact which appeared during these observations, and that which bears immediately on the remarks contained in the letter of M. de la Rive, is that there is a daily movement of the galvanometer needle, similar to that of the horizontal magnetic needle, produced by the electric currents travelling in one direction from about 8 A. M. to 8 P. M., and returning in the opposite direction during the remainder of the twenty-four hours. The times of zero are not regularly maintained and vary from 7 to 10 o'clock both in the morning and evening; but the greatest regularity is observable in the morning, and the mean result of numerous observations is as above stated.

This regular diurnal movement of the galvanometer needle is subject to disturbances of greater or less force and duration, which are found to be of greatest energy during magnetic storms, and when an aurora is visible; and in these cases the currents are so strong as to affect the ordinary telegraph instruments, and sometimes prevent altogether the transmission of messages.

The next experiments were made with a view to ascertain the direction in which these currents alternate; and the result, as determined from numerous observations, denotes it to be from northeast to southwest. The nearer this line is approached, the more decided is the effect on the galvanometer; but between east and south, and between north and west, the effect is smaller; and in approaching northwest and southeast, it becomes indefinite and irregular, but never ceases entirely.

It also appeared that the effect depended, not on the direction of the wire itself, but on the relative directions of the two earth connections; that is, the points where the wire was connected with the earth. I next made simultaneous observations with the galvanometers and a declinometer needle; from which it appeared, taking the mean of numerous observations, that that part of the day in which the currents flow southwards (that is, from 8 or 9 A. M. until the evening), the variation of the declinometer needle is westerly; and that during the night and early part of the morning (at which time the currents travel northwards) the variation is easterly; also, that the large disturbances called magnetic storms are simultaneous on both instruments.

But although there is this resemblance in the general features of the movements of both needles, the paths described are not similar. The movements of the galvanometer needle are more frequent and rapid than the declinometer, and the deflection frequently changes over from right to left without a corresponding movement of the declinometer.

The observations thus briefly recorded formed the subject of a paper which was read at the Royal Society on the 17th of June, 1847; and I have thought it desirable to make this communication to your Journal on reading M. de la Rive's letter, because it rather curiously happens, that the unusual delay which has arisen in the publication of my paper by the Royal Society is attributable to the fact, that I arrived from these experiments at the same conclusion as M. de la Rive, as to the electric origin of the diurnal variation of the magnetic needle, which I considered to be the effect of the alternating electric currents exhibited by the telegraph wires.

The Royal Society were unwilling to give their sanction to this view of the case, and only consented to the publication of the observations above described on my omitting that portion of the paper.

The paper is, however, now in the hands of the printers, and will I hope, be shortly before the public.

I ought to state in conclusion, that my idea of the origin of the currents differs in one respect from the theory of M. de la Rive; inasmuch as he considers them to rise in the atmosphere, whereas I have attributed them to thermo-electric action in the crust of the earth. I speak of course with great deference on a subject of this kind; but there is an important fact tending to this conclusion which is now well ascertained, namely, that in the telegraphs which are laid entirely under ground, deflections occur similar to those before described; while wires suspended in the air exhibit no deflections, unless they are connected with the earth in two places, and then the direction in which the current travels depends on the relative positions of the earth connections, however circuitous may be the route of the wire itself.

Derby, April 12, 1849.

5. *The Ruins of Nineveh*, (London Lit. Gaz., March 9, 1850, from The Times).—A correspondent has favored us with the subjoined extracts from the letter of Mr. Stewart Erskine Rolland, late of the 69th Regiment, who is now at Nimroud with Captain Layard, assisting him in his endeavors to bring to light the hidden antiquarian treasures of Nineveh. The difficulties which the gallant and enterprising discoverer has to contend with, owing to the limited pecuniary resources at his disposal, are dwelt on by our correspondent, who fears that the French antiquarian agent recently despatched will, with his much larger funds (30,000*l*. it is stated), materially encroach on the harvest of antiquities which would fall to the lot of the English nation, were Capt. Layard's exertions backed by more ample means:—

"The first two or three days at Mossul I spent in examining the excavations of Koyunjik, where fresh slabs are being every day brought to light. Two new colossal bulls and two colossal figures were discovered while I was there, at the entrance of the city gates; and the pavement at the gateway, marked with ruts by the chariot wheels, was also uncovered. I left my wife under Mrs. Rassam's care, and accompanied Layard a day's journey to the villages of Baarshekah and Bamyaneh, and to the mound of Khorsabad. We took greyhounds with us and had a day's hunting, catching seven antelopes. After our return, Mr. Layard, Charlotte, and I, and our servants, embarked on a raft, and floated down the Tigris in seven hours to this little village of Nimroud, close to a large mound, which was the first excavated, sending our baggage and horses by land. We have since been residing in his house here; it is, in fact, little more than a mud hut; but he has put in glass windows, a table, and some sofas, and made it as comfortable as circumstances will admit. Layard has placed a party of the workmen under my control, and allowed me to dig where I please. I am sinking wells in all directions, and am not without hopes of discovering subterranean chambers, which I am convinced must exist. In one place considerably below the level of any of the hitherto discovered monuments, a brick arch between two walls of brick has been uncovered: it is a puzzle to us all. Another great discovery is an immense stone wall of most solid masonry inside the brick pyramid. The workmen are laboring to force an entrance into it; but their progress is necessarily very slow, not exceeding a foot or two in a day. But the greatest discovery yet made since the earth was first turned remains to be told. I will give it you in due order.

"*January* 3, 1850.—On the 28th of December, Layard and I, with our attendants and two or three Arab Sheikhs, started off to pay a visit to the 'Tai,' on the other side of the 'Zab.' We were the first Europeans who had ever visited that country. Three hours' galloping from Nimroud brought us to the banks of the stream, which is as rapid and broad as the Tigris, and nearly as deep, but here, being divided into four branches, is fordable. With some difficulty we swam our horses across it, getting of course very wet in the operation. Our visit here has a threefold object—first, to explore the mound of Abou Sheeta, which appears to contain a buried city; secondly, to make friends between two rival chiefs of the Tai; and, thirdly, to promote a reconciliation between them and their implacable enemies, the Jibours, which will much facilitate Layard's future operations. Our first visit was to the camp of the Hawar, who is considered by all the Arabs, even by those of the great African desert, to be the highest born and noblest among them. He is probably the man of most ancient descent in the world, reckoning his genealogy far above the time of Abraham. He is supported in his pretensions to the chieftainship by the noblest of the tribe, while his rival, Feras, is supported by the Turks and the greater number of the Tai. His brother, the handsomest man I have ever seen, came out to meet us with 100 horsemen, most of whom had come to our village to plunder the other day. They galloped madly about the plain, brandishing their long spears, shouting their war cry, and escorted us in great state to the camp of the Sheikh, where he stood to receive us. I never saw so noble or dignified a figure; he is eminently handsome, though advanced in years and suffering from ill-health. In stature he is gigantic—six feet four or five at least, and erect as a pine tree. His tent was a spacious one, a load for three camels, with the women's tents on one side and that of the horses on the other, all under the same covering. Mats and cushions were spread on the floor of the tent, on which the Hawar, Layard and I sat, as did his brother, his uncle, and others of the magnates of the tribe, while the rest stood in a semicircle at the door. A noble hunting hawk stood on his perch in the centre. We partook of spiced coffee, discussed the business on which we came, and dined in the tent on a capital stew of mutton, pumpkins, rice, and sour milk. After we had partaken, the rest of the tribe made their repast, a certain number sitting down together, each man rising when he was satisfied, and a sort of master of the ceremonies calling out the name of the man who was to succeed him. There was no bustle or indecorum. After dinner they all said their prayers. We had set on our tents, which, by the way, got very wet in crossing the river, and we pitched them close to that of the Sheikh. The next day the encampment changed its quarters. I have seldom seen a more picturesque sight. The Sheikh's tent was struck first, and the long procession of laden camels, horsemen, donkeys, and cattle, stretched as far as the eye could reach. I calculated that there were about 2,000 persons with their camels, horses, and cattle. We paid our visit to Feras, the rival Sheikh, taking with us the brother of Hawar. We were well received, though not with the same dignified courtesy. While we were away the workmen had opened a trench, by Layard's direction, to show my wife a certain slab which he had buried; in doing so they uncovered three copper cauldrons of immense size, and some huge dishes of metal. Layard carefully removed the earth from one cauldron, which was partially filled with it, and discovered an immense variety of ivory ornaments, an iron axe-head, and innumerable other articles, which for the present I must forbear to mention, having promised secrecy. Layard removed as many as he could, and covered the rest with earth. It is by far the most important discovery that has yet been made. He has placed them under my charge, and given me the direction of the workmen, as he is obliged to go to Mossul to make preparations for the removal of the two finest colossal lions that have yet been discovered, which will, I trust, be on their way to England in a month or two. After that we shall cross the Zab with our tents, encamp there, and pass our time alternately in hunting and digging in the mound. You can have no idea of the difficulties Layard has had to contend with, or the energy, talent, perseverance, and shrewdness with which he surmounts them, or the exquisite tact and good humor with which he manages the different people he has to deal with. In the first place he has nothing but conjecture to guide him in his researches; it is literally groping in the dark, and all sorts of buried treasures may lie within his reach, while from the very small amount of funds placed at his disposal, he is unable to make anything like a proper search, and contents himself with sinking trenches almost at hazard as it were.

"*Jan.* 6.—Yesterday we removed more than thirty metal vases, bowls and saucers, most beautifully embossed and engraved, some shields and swords, of which the handles alone remain, the iron blades being decomposed, and a small marble vase. The cups and bowls and other ornaments are of some unknown alloy of metals, but they are all so encrusted with decomposed and crystallized copper, and so fragile, that they cannot be handled without great danger, and Mr. Layard is sending them home in the state in which he found them, without attempting to remove the rust. I spent eight hours yesterday in scratching them out of the clay with my hands, as the operation was too delicate to allow even a knife to be used. My wife was employed the whole night in packing them. We may now congratulate the British nation in being possessed of an entirely unique collection, the value of which is inestimable. The ornaments and sculptures on the vases denote a very advanced stage of civilization. Not the least curious of the discoveries are several hundred mother-o'-pearl studs, in form exactly resembling our shirt buttons.

6. *Oak Orchard Acid Spring Water, Alabama, Genesee Co., N. Y.;* by H. Erni, Assistant Chemist of the Yale Laboratory; and by Wm. J. Craw, of the same Laboratory.—This water is clear and transpa-

rent and without smell. It contained always a small sediment of organic matter, and tasted strongly acid, affecting the teeth; spec. grav. as found by Mr. Erni, 1·00482 at 15° C. 1000 pts. of the water yielded—

	Erni.	Craw.
$\dddot{\mathrm{S}}$	3·5706	3·532
$\dot{\mathrm{Fe}}$	0·2065	·2258
$\dddot{\mathrm{Al}}$	0·1111	·0966
$\dot{\mathrm{Ca}}$	0·4557	·4596
$\dot{\mathrm{Mg}}$	0·1562	·1805
$\dot{\mathrm{K}}$	0·0571	·0444
$\dot{\mathrm{Na}}$	0·0522	·0412
Na	.....	·0143
Cl	.....	·0220
$\dddot{\mathrm{Si}}$	0·0656	·0684
Chlorine and organic matters,	*traces*	....
	4·6750	4·6848

Representing the bases as combined with SO_3, we have for the composition of 1000 pts. of water—

	Erni.	Craw.
$\dddot{\mathrm{S}}$	2·0122	2·0070
$\dot{\mathrm{Fe}}\,\dddot{\mathrm{S}}$	0·4356	·4266
$\dddot{\mathrm{Al}}\,\dddot{\mathrm{S}}^3$	0·3702	·3232
$\dot{\mathrm{Ca}}\,\dddot{\mathrm{S}}$	1·1065	1·1161
$\dot{\mathrm{Mg}}\,\dddot{\mathrm{S}}$	0·4592	·5305
$\dot{\mathrm{K}}\,\dddot{\mathrm{S}}$	0·1061	·0822
$\dot{\mathrm{Na}}\,\dddot{\mathrm{S}}$	0·1196	·0945
Na Cl	.....	·0363
$\dddot{\mathrm{Si}}$	0·0656	·0684
Chlorine, organic matter,	*trace*	....
	4·6750	4·6848

Yale Laboratory, April 18, 1850.

7. *On the Cause of Auroræ Boreales;* by AUGUSTE DE LA RIVE, being an extract from a letter to M. Regnault, (Comptes Rendus, Oct. 15, 1849; Phil. Mag., xxxv, Dec., 1849.)—I have just read, in a memoir by M. Morlet on the Auroræ Boreales, inserted in the *Annales de Chimie et de Physique*, 3d series, vol xxvii, the following passage:—

"With regard to the origin of this luminous matter (that of the aurora borealis), it seems natural to attribute it to the electric fluid contained in the atmosphere, and which at great heights where the air is rarefied, must become luminous as under the receiver of the air-pump and in the barometric vacuum: this hypothesis would acquire a great probability if we succeeded in proving by direct experiments, that magnetism exerts an influence on electric light."

This last expression induces me to request you to have the goodness to communicate to the Academy of Sciences an experiment which I mentioned to you on my passage through Paris last June, and which you may perhaps remember; its object was to show, in support of the theory which I had advanced of the aurora borealis, the influence exerted by magnetism upon the light which is produced in ordinary electric discharges. Hitherto this influence has only been shown in the case of the luminous arc which escapes between two conducting points, each communicating with one of the poles of a voltaic battery; which is very different, both as concerns the phenomenon itself, and in what concerns its application to the theory of the aurora borealis. The following is my experiment.

I introduce into a glass globe about thirty centimetres in diameter, by one of the two tubulures with which it was furnished, a cylindrical iron bar, of such length that one of its extremities reaches nearly to the centre of the globe, whilst the other extends from three to four centimetres out of the tubulure. The bar is hermetically sealed in the tubulure, and covered throughout its length, except at its two ends, with an isolating and thick layer of wax. A copper ring surrounds the bar above the isolating layer in its internal part the nearest to the side of the globe; from this ring proceeds a conducting rod, which, carefully isolated, traverses the same tubulure as the iron bar, but without communicating with it, and terminates externally in a knob or hook. When by means of a stop-cock adjusted to the second tubulure of the globe, the air in it is rarefied up to three to five millimetres, the hook is made to communicate with one of the conductors of an electric machine, and the external extremity of the iron bar with the other, so that the two electricities unite in the interior of the globe, forming between the internal extremity of the iron bar and the copper ring which is at its base, a more or less regular fascicle of light. But if the external extremity of the iron bar is placed in contact with one of the poles of a strong electro-magnet, taking good care to preserve the isolation, the electric light takes a very different aspect. Instead of issuing, as before, from the different points of the surface of the terminal part of the iron bar, it is emitted only from the points which form the contour of this part, so as to constitute a continuous luminous ring. This is not all: this ring, and the luminous jets which emanate from it, have a continuous movement of rotation around the magnetized bar; one while in one direction, at other times in another, according to the electric discharges and the direction of the magnetization. Lastly, more brilliant jets appear to issue from this luminous circumference without being confounded with those which terminate on the ring, and form the fascicle. As soon as the magnetization ceases, the luminous phenomenon becomes again what it was previously, and what it is generally in the experiment known by the name of the *electrical egg.* Not having any powerful machine at my disposal, I used for my experiment an Armstrong's hydro-electric machine, the boiler of which I made to communicate with the copper ring, and the isolated conductor which receives the vapor with the iron bar, or *vice versa* when I wished to change the direction of the discharges. The experiment succeeded very well in this manner.

The experiment which I have just described appears to me to account very satisfactorily for what passes in the phenomenon of the aurora borealis; in fact, the light which results from the union of the two electricities in the part of the atmosphere which covers the polar regions, instead of remaining vaguely distributed, is carried by the action of the terrestrial magnetism round the magnetic pole of the globe, whence it seems to rise in a revolving column, of which it is the base. We thus understand why the magnetic pole is always the apparent centre whence issues the light constituting the aurora borealis, or toward which it appears to converge. I shall not recur to the other circumstances which accompany this meteorological phenomenon, the agreement of which I have shown with the explanation I have given in a letter addressed to M. Arago, which was communicated to the Academy, and inserted in the Philosophical Magazine for April, 1849, p. 286.

But, having referred to this letter, in which the question was also raised respecting the explanation of the diurnal variations of the magnetic needle, permit me to add, that I have had occasion to prove, in England, both by my own observations, and still better by the more extensive ones of several physicists,* the existence of electric currents having a direction from the northwest to the southeast on the surface of the earth. The presence of these currents can be easily proved by means of the metallic wires which serve as telegraphic communications: wires which are placed underground and at the same time well isolated, except at their two extremities which dip into the ground, are best suited for this kind of observations. It is very curious to follow the agreement which exists between the variations of intensity of these currents and the variations of magnitude of the deviation of the magnetic needle of declination; a new proof to add to that drawn from their direction, that they are the cause of the diurnal variations.

Colonel Sabine has stated, in opposition to my explanation of the diurnal variations, an objection drawn from the observation on these variations at the Island of St. Helena and at the Cape of Good Hope.† I do not think it well founded, and, without entering into the details which will better find a place elsewhere, I shall limit myself to one single remark. I attribute the origin of the currents which give rise to the aurora borealis and to the diurnal variations, to the rupture of the electric equilibrium occasioned, in each atmospheric column, by the difference of temperature which exists between its base which reposes on the surface of the globe and its upper part which is at the limit of the atmosphere. Each column thus forms a kind of pile charged at its two extremities with contrary electricities, which unite in part by the pile itself, in part by a circuit formed of the upper regions of the atmosphere, of the atmospheric polar regions, and of the surface of the earth. Meteorological circumstances determine the greater or less proportion of the two electricities which unite by one or the other of these ways.

Now, the temperature of the base of the column must vary not only with the season, with the time of the day, and with the latitude of the place where it is observed, but also with the nature of the surface of the globe on which it reposes. When, therefore, this surface is the sea, the hours of maxima and minima of temperature are not the same as when it is *terra firma*, all other circumstances being the same; it results necessarily that the hours of maxima and minima of intensity of the electric currents, and consequently of the diurnal variations to which they give rise, must be equally different. Now, St. Helena and the Cape of Good Hope may be considered as places enveloped in atmospheric columns, which have almost their entire base resting on the sea and not on the land; thence the anomalies pointed out by Colonel Sabine are very easily explained, and, in particular, it is easily understood how there is no agreement, in direction, which must in every case be different, between the diurnal variations observed at the Cape of Good Hope and those observed at Algiers, which is equally distant from the equator, but to the north. An excellent paper by M. Aimé on terrestrial magnetism, inserted in the *Annales de Chimie et de Physique*, 3d series, vol. xvii, in which he discusses comparatively the observations made at St. Helena, the Cape, and Algiers, has singularly facilitated the explanation of the anomalies presented as objections by Mr. Sabine.

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* See the observations of W. H. Barlow on this subject, Phil. Mag., vol. xxxiv, p. 344.

† Phil. Mag., vol. xxxiv, p. 466.

I, however, do not pretend that there does not exist any anomaly; my explanation is not more free than others from those which result from certain local and exceptional causes. I am not further from admitting that the currents of induction determined on the surface itself of the globe, by its rotation under the influence of its magnetic poles, cannot have any part in the phenomenon of the diurnal variations and aurora borealis, and account for the connection which these variations appear to have with the absolute direction both in declination, and in inclination of the magnetic needle, and with the absolute intensity of the terrestrial magnetism. But this subject would require, for elucidation, to be treated more at length than can be done in a letter; I shall therefore stop, and beg to refer those persons who may be interested in this question to a memoir which I am on the point of completing, and which will be published forthwith.

8. *Charleston Meeting of the American Association for the Advancement of Science.*—The semi-annual session of the American Association was held by appointment in Charleston, South Carolina, in the early part of March, and was attended quite as numerously as could have been expected. The season of the year, and the distance of a majority of members, made it impossible for a large concourse to be gathered. We have failed to procure a full list of the papers read at this meeting, no complete list having at a late date been received from the Secretaries. That the papers were numerous and of importance, we know from the testimony of those who were at the meeting. Dr. A. D. Bache presided at this meeting, and the greatest hospitality, public and private, was enjoyed both from the city and inhabitants. With a most commendable liberality, the City Council assumed all the expenses of the Association in publishing the volume of Reports of proceedings and papers at this meeting. This example so worthy of imitation, will we trust, be a precedent for the future reception of the Association. Such contributions are honorable to those who proffer them, just to the cause of science, and truly encouraging to the working men who sacrifice the hopes of accumulation to the sacred cause of truth for the general good.

The next annual meeting of the Association will be held at New Haven on the 19th of August next. The Local Committee will soon issue their circulars of invitation.

VI. BIBLIOGRAPHY.

1. *Proceedings of the American Association for the Advancement of Science*, second meeting. Held at Cambridge, August, 1849. Boston, 1850. H. Flanders & Co. 8vo, pp. 459.—This volume is composed mainly from the reports made at the time and printed in the Boston Traveler, which have since been corrected by the several authors and are now issued under the sanction of the publishing committee. It is a volume of abstracts rather than one of full papers, although many of the shorter papers are given in full detail. The volume covers a wide range of subjects in all departments of science and evinces a high degree of activity in physical investigation, much greater probably than has existed at any former period of American history. Many of the most important articles it contains have already appeared in this Journal, and others will find their way into it.

2. *The Annual of Scientific Discovery, or Year Book of Facts in Science and Arts, &c.;* edited by DAVID A. WELLS (of the Lawrence Scientific School, Cambridge,) and GEORGE BLISS, Jr. Boston: Gould, Kendall and Lincoln. 1850. 12mo, pp. 392, with a portrait of Prof. Agassiz.—This annual is projected upon a comprehensive plan including the most important discoveries and improvements "in mechanics, useful arts, natural philosophy, chemistry, astronomy, meteorology, zöology, botany, mineralogy, geology, geography, antiquities, together with a list of recent scientific publications, a classified list of patents, obituaries of eminent scientific men, and an index of important papers in scientific journals and reports." This volume is properly a book of selections from the various scientific discoveries of the year past rather than a complete registry of them, and as such it is a work of great merit, and highly useful to the scientific as well as general reader. In a cursory examination of the volume we observe, however, errors and omissions in some departments which more care will in future avoid; and we would especially suggest more attention to American facts and researches, and the propriety of giving a fuller index of the articles in scientific journals and reports. There are numerous original and important memoirs published in the past year, in American publications, to which no allusion is made either in the index of articles or in the body of the work, a deficiency to which we should not allude were not the title so comprehensive as to be calculated to mislead scientific men abroad. We notice also several incorrect statements copied from the daily newspapers, e. g., those regarding the copper mines at Bristol and in Litchfield, in Connecticut. It is our wish to encourage a work in the main so excellent, by suggesting imperfections that may hereafter be avoided. We are glad to learn that a large edition of the book has already been exhausted.

3. *The Physical Atlas of Natural Phenomena;* for the use of Colleges, Academies and Families; by ALEXANDER KEITH JOHNSTON, F.R.G.S., F.G.S., American edition, Lea & Blanchard, Philadelphia, containing 26 maps in 4to, with interleaved text.—This atlas is an encyclopædia of knowledge relating to the physical character and phenomena of our globe, presented in a series of maps, with full descrip-

tions and a vast amount of added detail in the accompanying pages of letter press. The maps have been prepared with the skill and knowledge which none but the most extensive learning could command, and are so displayed by the use of colors and various designs as to speak decisively and intelligibly to the eye. The subject of geology is first presented, and the distribution over the earth of rock formations, including volcanoes, is seen in a general manner on Pl. 1. An elegant geological map of the British Isles is added. Another map or plate shows the distribution of mountain ranges, their exact courses and relations. The accompanying text treats of the mean heights and features of continents, highest peaks and general characters of chains. Another map is devoted to the Andes and Rocky Mountains with the ranges of America. Plate 4, illustrates in a very perfect manner the glacier system of the Alps; plate 5, very minutely and elegantly the distribution of volcanoes of the globe, and volcanoes and earthquakes are the subject of much important information in the text. In the same manner, there are several maps representing the distribution of the waters of the globe, their currents, temperature, tides, usual tracks of vessels, continental waters, river basins; others exhibiting the regions of rains, of deserts, the courses of winds and prevalent hurricanes; others, the vegetation, forest regions, distribution of plants and animals, and of races of men.

4. *Lake Superior, its Physical Character, Vegetation and Animals, compared with those of other and similar Regions;* by Louis Agassiz, with a narrative of the Tour, by J. Elliot Cabot, and contributions by other scientific gentlemen, with appropriate illustrations; pp. 428, 8vo. Boston: Gould, Kendall & Lincoln. 1850.

The narrative occupies 133 pages, and is drawn up with perspicuity, condensation and elegance; interspersed among the pages of the text are scientific remarks by Prof. Agassiz, on the various objects which presented themselves in the progress of the tour which was included between the 15th of June, and the 25th of August, 1848. Railroads and steamboats brought them speedily to and from the scene of action, and the seventy-one days were most industriously and successfully employed by the naturalists and pupils and amateurs in a party of sixteen, acting intelligently and vigorously under their distinguished and accomplished leader.

The most important scientific observations are given separately in an appendix to the narrative, and are included under the following heads.

Lake Superior—Physical character, Vegetation and Animals, compared with those of other and similar regions.

I. The northern vegetation compared with that of the Jura and the Alps.

II. Observations on the vegetation of the northern shores of Lake Superior.

III. Classifications of animals from Embryonic and Palæozoic data.

IV. General remarks upon the Coleoptera of Lake Superior, by Dr. John L. Le Conte.

V. Catalogue of Shells, with descriptions of new species, by Dr. A. A. Gould.

VI. Fishes of Lake Superior compared with those of the other great Canadian Lakes.

VII. Description of some new species of Reptiles from the region of Lake Superior.

VIII. Report on the Birds collected and observed at Lake Superior, by J. E. Cabot.

IX. Description of some species of Lepidoptera from the northern shores of Lake Superior, by Dr. Thaddeus William Harris.

X. The Erratic Phenomena about Lake Superior.

XI. The outlines of Lake Superior.

XII. Geological relations of the various Copper deposits of Lake Superior.

5. *A natural Scale of Heights by the application of which the Measures of different countries are reduced to a common measure known to all Geographers*, constructed by Miss Colthurst.—Presented to the Royal Geographical Society, by G. B. Greenough, V. P., [and by him forwarded to us.]—The standard is an equatorial, geographical mile, a fixed quantity universally known and derived from the figure of the earth =6086·78 English feet. Five of these miles being divided each into 100 parts or degrees, give a scale of 500 degrees each of which is equal to 60⅞ English feet.

The measures of different countries are arranged separately in parallel vertical columns, each with its own caption; and adjoining each on the left, is the scale derived from the centesimal division of the geographical miles, and the corresponding numbers or lines denote the values of the different measures.

6. *The East; Sketches of Travel in Egypt and the Holy Land;* by the Rev. J. A. Spencer, M.A. *With illustrations from original drawings.* G. P. Putnam, New York. pp. 503, 8vo, in cloth, gilt. 1850.—As the physical features of these countries form a prominent topic in this agreeable and instructive volume of travels, it may be properly mentioned in this Journal. It follows with advantage after the more elaborate works from which it quotes and sometimes dissents. Its moral tendency is excellent, although its amiable author in his winding up has often viewed objects through a colored medium, and his numerous apologies seem to us uncalled for. We have derived both pleasure and useful information from the perusal, and can cordially commend it.

7. *Man Primeval, or the Constitution and Primitive condition of the human being, &c.;* by John Harris, D.D., President of Cheshunt College, England. Reprint by Gould, Kendall and Lincoln, Boston, pp. 480, cloth. 1850.—Although this new work of Dr. Harris is a contribution to theological science, it has like its predecessor, "The Pre-adamite Earth," by the same author, such intimate relations to geology, and like that work, it presents such enlarged and just views of science, that it is entitled to respectful mention in this Journal.

8. *A Systematic Treatise, Historical, Etiological and Practical, on the Principal diseases of the Interior valley of North America; as they appear in the Caucasian, African, Indian and Esquimaux varieties of its Population;* by Daniel Drake, M.D. 878 pp. 8vo: Cincinnati, Ohio, 1850. Winthrop B. Smith & Co., Publishers, Philadelphia.—This very elaborate work treats first, of General Etiology, pp. 701; and secondly, of the Febrile diseases of the region, pp. 703–863. In Book I,

there are chapters on the topography, hydrography, and geological outline of the great western valley; on the hydrographical basin of the Gulf of Mexico, its currents, tides, temperature, &c.; on the special medical topography of places along the coasts of the Gulf of Mexico; the delta of the Mississippi, and river above, with the regions east and west of the river, and the basin of the Ohio, Alleghany and other tributary streams, tho basins of the St. Lawrence and Great Lakes, and the Hudson and Arctic hydrographical basins. Next the author treats at length of the temperature of the different basins, barometrical character, winds, rain, electrical phenomena, and whatever can have a bearing upon health. He then passes to the subject of population, its distribution and character, modes of life, diet, use of alcohol and tobacco, clothing, occupations or pursuits. Book second contains full descriptions of the various diseases, as to their many forms and symptoms and modes of treatment.

Dr. Drake is undoubtedly the most able man in America for so difficult a task. It is well known, he has for many years investigated the subject with characteristic ardor, and in the research has personally visited all parts of the West and South, making at many places anxious and laborious observations—medical, statistical and physical.

9. *Transactions of the Society of Arts for* 1846–7 *and* 1847–8. 1847, 1849.—The Society of Arts commenced in 1847, a new series of their publications, and have issued Parts 1 and 2 of the first volume. These transactions are elegant in style of typography and illustration, abounding in colored plates of great interest and beauty, and the memoirs are valuable contributions to the Arts. They treat of carving, cameo making, steam boilers and locomotives, atmospheric electricity, of beauty, artificial lava for ornaments, ancient Greek vases, steam navigation, lighthouses and beacons, lithography, ancient and modern bookbinding, photography, cotton of Honduras, and various other subjects of general interest.

10. *A Universal Formulary, containing the method of preparing and administering officinal and other Medicines, the whole adapted to Physicians and Pharmaceutists;* by R. EGGLESFELD GRIFFITH, M.D., 568 pp., 8vo, Philadelphia. Lea & Blanchard.—The Universal Formulary of Prof. Griffith has the completeness which its title implies, and is exceedingly convenient in arrangement. The body of the work is preceded by a long introduction containing comparative tables of weights and measures, United States and foreign, explanations of abbreviations and terms in use, with observations on the management of the sick room, and rules for the administration of medicines. The formulary is arranged alphabetically, according to the pharmaceutic names adopted in the United States pharmacopeia; the English appellations of articles are used, and the quantities are expressed in words instead of pharmaceutical signs. Copious indexes are added not only of the formulas, but of the diseases for which they are advised.

T. A. CONRAD: Descriptions of one new Cretaceous and seven new Eocene Fossils from Georgia.—By T. A. Conrad, from the Journal of the Acad. Nat. Sci., Philad., [2], ii, part 1, p. 39. March, 1850. 7 species are Echinoderms and the rest Mollusca.

C. B. Adams: Monograph of Vitrinella, a new genus of Turbinidæ, with new species; by C. B. Adams. 10 pp. 8vo. Amherst, Mass. [Generic description, "Testa, turbiniformi, minimâ, vitreâ; aperturâ maximâ, orbiculari, subtus valde indentatâ vel umbilicata."—Distinguished by the vitreous texture of the shell, and the rapid enlargement of the whorls, producing a large aperture. Species from Jamaica.]

C. B. Adams: Contributions to Conchology, Nos. 5 and 6. 32 pp. 8vo. Amherst. —No. 5 contains new marine and terrestrial shells from Jamaica. No. 6, a memoir on the origin of the terrestrial molluscs of Jamaica; together with a description of a new genus of Helicidæ, *Spiraxis;* and notes on certain species of the land shells of Jamaica and descriptions of supposed new species.—[Genus Spiraxis is described as follows: "G. t. parvâ, turritâ; columellâ medio in laminam spiralem productâ: aperturâ ovali, medio partim divisâ: labro simplice." The *Achatina aberrans* of Pfeiffer is supposed to be identical with the author's Spiraxis aberrans.]

John W. Herschel: A Manual of Scientific Enquiry, prepared for the use of her Majesty's Navy, and adapted for travelers in general; published by the Lords Commissioners of the Admiralty; 488 pp. 12mo. *London*, 1849.

W. Baird, M.D., F.L.S.: The Natural History of British Entomostraca. 364 pp. 8vo, with 36 lithographed plates; published by the Ray Society.

A Sketch of the Medical Botany of South Carolina; being a Report made to the American Medical Association at its Sessions in Baltimore and Boston; by Fran. Peyre Porcher, M.D. (From the Trans. of the Amer. Med. Assoc., vol. II.) Philadelphia, 1849.

S. Chase, Prof. Math. Dart. Coll.: A Treatise on Algebra, 336 pp. 12mo. *New York*, 1849; D. Appleton & Co.

The Astronomical Journal. Nos. 5, 6. March.—These numbers contain—Development of the Perturbative Function of Planetary Motion, by B. Peirce, continued. —Observations of Astræa for 1847, by Prof. S. Hubbard.—On unlimited Spherical Triangles and their solution, by Wm. Chauvenet.—Ephemeris of Neptune; S. C. Walker.—Observations of Astreæ, by Mr. James Ferguson.

Proceedings of the Boston Soc. Nat. Hist. MAY, 1849.—p. 150. On Algerite, a new mineral; *Dr. Bacon.*—p. 151. New shells of the U. S. Exploring Expedition (genera Buccinum and Nassa); *A. A. Gould.* JUNE.—p. 158. On the embryonic development of Campanularia; *Desor.* JULY.—p. 163. Description of Percopsis pellucida, a new fish; *Z. Thompson.* AUGUST.—p. 166. On the epithelial tissues; *W. J. Burnett.*—p. 168. Animalcules in blood; *Burnett.*—New shells of the Exploring Expedition (genera Columbella, Mitra, Conus); *A. A. Gould.* SEPTEMBER.—p. 172. On the Esox lucius of Richardson; *Ayres.*—p. 175. A new species of Helix, (H. exigua), found near Boston; *Stimpson.* OCTOBER.—p. 178. On two malformed skulls of the Cod; *J. Wyman.*—p. 179. On the Cranium of the Troglodytes gorilla; *J. Wyman.* —p. 181. New species of fish of the genus Polypterus, from West Africa; *Ayres.*—p. 182. Tooth of Troglodytes gorilla; *J. Wyman.*—p. 182. Scratched rocks of the coast of Labrador; *J. Wyman.*—p. 183. On the genus Cottus; *Girard.* NOVEMBER.—p. 190. On some peculiarities of Annelids; *Agassiz.*—p. 191. On four new species of Doris; *Agassiz.*—p. 192. Skulls of female Eel; *Ayres.*—Cranium of a Manatee; *J. Wyman.*

Proceedings of the American Philosophical Society, v, No. 44. Oct., March, 1850.—p. 108. Observations on the radiation of heat by air; *Henry.*—p. 117. On the alleged influence of the moon on the weather; *T. Gilpin.*—p. 125. Remarks on a memoir by Delgado on the disc of the Emperor Theodosius, presented to the Society by the Royal Academy of Madrid; *Trego.*—p. 127. On the original purchase of land in Pennsylvania and the celebrated "Indian Walk;" *Trego.*—p. 139. Observations on the occultation of Jupiter and his Satellites, Feb. 26, 1850; *Kendall.*

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* Incorrectly spelt Garric.

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ERRATA.

Page 39, line 13 from bottom, for "John Garric, M.D.," read "John Gorrie, M.D."

Vol. ix, p. 277, 2nd line from bottom, for "carbonates," read "carburets."
" " " 281, 5th " " " for "zinc," read "lime."
" " " 239, 3d " " " for 67, read 87, and at top of next page, for 3 : 2, read 2 : 1, and for "one-half," read "the same."
Vol. ix, p. 422, 5th line from top, for "volume," read "weight."
" " " 409, 10th line from top, transpose 72·47 and 27·53.
" " " 429, 19th " " " for "pyroxene," read "borax."
Vol. x, p. 138, 2nd paragraph, for *Souyet*, read *Louyet*. See further, p. 414.

THE

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JOURNAL OF SCIENCE AND ARTS.

[SECOND SERIES.]

Art. I.—*Review of the Geological Report on the Chippewa Land District of Wisconsin and part of Iowa, made in the year* 1847, *under the direction of D. D. Owen, M.D.*, U. S. Geologist for Wisconsin and Iowa.

In our last volume we gave a brief notice of a geological survey of the Chippewa Land District of Wisconsin and a part of Iowa; made under instructions from the Secretary of the Treasury of the United States and conducted by Dr. D. D. Owen as principal Geologist aided by Dr. J. G. Norwood as Assistant Geologist, and by the following gentlemen who conducted the operations of the sub-corps: Dr. A. Litton, Dr. B. F. Shumard, Mr. B. C. Macy, Mr. John Evans and Mr. A. Randall.

We propose in the present number to give a further brief review of that report setting forth the general and most important results.

The report now before us contains only an account of the field operations of the U. S. Geological corps engaged in the above district during the summer and autumn of 1847, and is therefore only the commencement of the work continued in 1848 and 1849.

The situation and extent of the country examined is given on page 8 of the report as follows:

"The seat of operations of the party appointed to explore the mineral lands of Wisconsin and a portion of Iowa was, during the summer and autumn of 1847, in a portion of country lying chiefly east of the Upper Mississippi above Lake Pepin, and extending north to Lake Superior. There was, however, also included a portion of Iowa, stretching north from the northern boundary of the geological survey of 1839, as far as the St. Peter's river; and also a tract of country north of the Wisconsin river. The principal streams which water it are Black river, the Chippewa, and the St. Croix, flowing southerly into the Mississippi; Mauvaise-Riviére, (Bad river,) and Bois Brulé, (Burnt Wood river,) falling into Lake Superior; and Turkey river, Upper Iowa, Hokah, Miniska, Wazi Oju, Cannon, Vermillion, and a portion of St. Peter's flowing eastwardly into the Mississippi. It comprehends so much of the Chippewa land district as lies within the boundaries proposed for the State of Wisconsin, the southern part of the country bordering on the Kickapoo, together with the chief part of the Winnebago reserve, the half breed tract and a strip of the Sioux country west of, and adjacent to, the Mississippi, and reaching north to the St. Peter's.

"It lies between 43° and 47° north latitude, and between 89° and 94° of longitude west of Greenwich, and embraces about forty-six thousand square miles of surface."

In addition to the general reconnoissance made of the above region of country, a detailed survey was made of about thirty townships, west of the 4th P. M. on Black river in latitude 44° 30′, and about sixty townships on the St. Croix river in latitude 45°. Nineteen sections have been constructed by Dr. Owen and the other gentlemen of the corps at the most important points on the Mississippi, and six on the St. Croix arranged in such a manner as to form a diagram of comparative heights, not only of the outline of the country, but also of the principal members of the prevailing geological formations. One continuous section extends from the mouth of the Wisconsin, where the survey of 1839 terminated, to the Falls of St. Anthony; one from the Mississippi to the Falls of the St. Croix; one from the mouth of the St. Croix to the Falls of St. Anthony on a more extended scale than that appended to the general Mississippi section; one from Lake Superior to Portage Lake; one from the head waters of Wisconsin river to the Dalles of that river; one from Lake Superior to the Falls of the St. Louis river; one from Lake Superior along the 4th P. M. to Black river, and thence to the Mississippi; one along the correction line from the 4th P. M. to the Mississippi; one from the Kinikinick in a southwest direction across the St. Croix. Also a particular section at the Falls of St. Anthony. Diagrams of summit levels show the relative elevation of ground between the Mississippi and Lake Superior in three different directions.

Several of the above sections are so contrived with landscape back ground, as to present not only the natural exposure of rock, but also the general outline and appearance of the country through which the sections run.

The report is also illustrated by a *provisional* geological chart showing the approximate boundaries of formations; and by twenty-three sketches exhibiting the geological features of the landscape.

The geology of the district is described under the following heads:

1. Formations of the Upper Mississippi.
2. Formations of Red Cedar river and the Winnebago reserve.
3. Formations of the interior of the Chippewa Land District.
4. Formations of Lake Superior.
5. Drift.

In our notice of these topics we must necessarily confine ourselves to leading results.

It appears that the Upper Mississippi country north of the Wisconsin river to within a short distance of the mouth of the St. Peter's, is based on the magnesian limestones and sandstones older than the lowest of the formations of the valley of the Ohio; a portion of them being cotemporaneous with the calciferous group and Potsdam sandstone of the New York survey.

The portion of the report relating to these formations, which will be read with peculiar interest, is that which relates to the fossiliferous beds of these formations, since hitherto they have been regarded as almost barren of organic relics.

The results of this survey seem to show that it is to this portion of the United States that we must look to throw most light on the earliest organic forms.

On this subject we find on page 14 the following paragraph:

"If we except the white sandstone the terminating mass of F. 1 e,* the one upon which the lower† magnesian limestone (F. 2) rests, nothing definite was known up to the period of the present survey, of the nature or character of the underlying beds just described. Neither had any well defined organic remains been described anywhere beneath the grey and blue fossiliferous beds which form the upper portion of the sections at Prairie du Chien; so that there was an entire absence of all palæontological evidence as to the exact place which these strata occupied in the geological series. It is, therefore, with no small degree of satisfaction that I find myself able, from the observations of last summer, to disclose a new feature in the palæontology of Western America, and thus to furnish, not only to the geologist, a key to the stratigraphical position of the rocks north of the Wisconsin river, but, at the same time, to the miner his surest and safest guide by which to direct operations in the search after mineral wealth.

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* The lowest bed at the mouth of the Wisconsin river.

† In contradistinction to the upper magnesian limestone, the lead bearing rock of the Mineral Point District. Se report of 1839.

"More than one half of the above series, supposed at first to be quite barren of all organic forms, has already been proved fossiliferous, and subsequent search will no doubt develop others.

"It is, moreover, worthy of remark that the most fossiliferous portion of F. 1 is not its upper part, but beds which lie quite low down, even seven to eight hundred feet beneath what was, up to this time, considered the limit of the fossiliferous strata of the Mississippi valley. Yet these strata prove to be as densely crowded with organic relics as any of the most fossiliferous strata of the blue limestone of Ohio, Indiana, and Kentucky. The proportion of genera and species, it is true, is not great, but the number of individuals is immense; some slabs are so covered with shells, that it would be difficult to place the finger on a spot without touching some of them. The prevalent genera are *Lingulas* and *Orbiculas;* yet associated with these are some remarkable forms of crustaceans. The specimen figured on Pl. 7, fig. 1, is the pygidium of a peculiar trilobite, armed with spinous processes projecting from its posterior margin. I obtained it in thin bedded silico-calcareous layers near the level of low water mark below Mountain Island, in connection with schistose gritstones. The latter are charged with very perfect specimens of a small fossil shell having a nacreous lustre closely allied to *Obolus Apollinis* of Eichwald, which are found by thousands in the inferior sandstones of the protozoic strata of Russia. Associated with these shells are also found remarkable compressed sub-conical bodies, the nature of which I have not fully determined; but they are, perhaps, spines of much larger trilobites than the one represented on Pl. 7, F. 1. Yet these beds are identical with layers near low water at Mountain Island, entirely beneath a Lingula sandstone which, in all probability, is the western equivalent of the Lingula beds of the New York Potsdam sandstone, considered by most American geologists the oldest fossiliferous rock in the United States. The imbedded species of each seem the same, as far as one can judge from mere casts. At a little higher geological level, between Prairie a la Crosse and Bad Axe, I obtained numerous casts of Orthis in an impure, dark, flesh-colored, calcareous rock, associated with bucklers of a species of trilobite, which appears to be new. In a similar rock, near the foot of La Grange mountain, I also observed casts of Delthyris beneath green sandstone. (F. 1 c.)

"About the same geological horizon, in an argillo-calcareous rock, near the level of the head of Lake St. Croix, is a very large species of *Asaphus*, the buckler and post-abdomen of which is figured on Pl. 7, Fig. 2 and 3. Finally, at Marine Mills, ten miles above Lake St. Croix, only eighteen or twenty feet higher, viz.: in F. 1 e, in a soft gritstone, are abundance of bucklers and post-abdomens of small trilobites, possessing some analogies in form to the genera *Agnostus*, *Trinucleus*, and *Triarthrus*, (see Pl. 7, Fig. 4,) and probably belonging to more than one species; one of which seems to have been provided with spines, at least two inches in length, curved at the extremity into the form of a barbed fish hook. Fig. 5, Pl. 7, represents one of these, found by Mr. B. C. Macy near the mouth of Miniskah."

Speaking of the distinction between the *lower* and *upper* magnesian limestone formations of the Upper Mississippi, Dr. Owen remarks, page 19:—

"The traveller who has visited the Upper Mississippi cannot fail to have remarked the peculiar outline of hill that bounds the prospect on either side of this picturesque portion of that majestic river. He must especially have noticed the conspicuous perpendicular walls of rock, that rise from out the grassy slope, or green copse wood, in massive cliffs, and terrace the heights as with interrupted natural battlements from the Maquoketa river to Lake Pepin. It is not, however, until the geology of the country has been closely inspected, that he is able to discover that the hills which present themselves to view below Turkey river do not belong to the same geological era as those which appear above the mouth of that stream. Nay, so uniform are they in their general aspect, that the miner himself, who has spent the best part of his days in excavating and exploring their recesses, is wont to regard them as identical. So they are, looking only to their chemical composition. Both are limestones, highly magnesian,* in heavy beds, of great compactness and durability; but they are separated from each other by from one hundred and fifty to two hundred feet of other strata, the upper hundred feet of which teem with peculiar races of fossil forms, constituting a distinct geological epoch, and marking a long lapse of time that has intervened between the period of deposition of these limestones. In my former report I have designated them the "lower" and "upper" magnesian limestones of Wisconsin and Iowa. This distinction, as will appear more fully hereafter, is of the first importance in drawing conclusions regarding the mineral value of the country I have been instructed to explore.

"All the conspicuous escarpments of magnesian limestone, south of Turkey river, are composed of the upper of these formations, whilst all those north of Wisconsin river, as far as Lake Pepin, are of the lower.

"An inspection of hand specimens is in general not sufficient to enable even the geologist to determine from which of these magnesian limestone formations it has been taken, so like are the two in general aspect. Viewed on a large scale, however, some distinctive peculiarities can be observed; the lower magnesian limestone has both in its upper and lower portion often oolitic beds interstratified; it has occasionally green particles disseminated through it, and on the whole is rather more compact and darker colored. The only certain methods, however, of determining to which of these formations any given rock belongs, is to note the order of superposition; or, still better, to determine the nature of the imbedded organic remains, which differ materially in the two."*

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* The proportion of carbonate of magnesia varies from 10 to 42 per cent.

One of the most important results of the survey is the establishment of the fact that the *lower* magnesian limestone as well as the upper, is metalliferous, yielding both galena and copper ore similar to that found south in the Mineral Point District in the upper magnesian limestone.† It appears, however, as yet a matter of doubt whether these ores will be found in as rich profusion in the northern part of Wisconsin as in the Mineral Point and Du Buque Districts.

The lower sandstones of the Upper Mississippi were found to attain their greatest elevation and development a few miles below Mountain Island, or, as it is known to the French Canadian, "*Montagne qui trempe a l'eau.*"‡ From thence with some few irregularities, as indicated by the diagram of comparative heights,

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* The paragraphs describing in a graphic manner the physical features of this magnesian limestone, are cited in our last volume on page 307.

† In confirmation of the correctness of the statistics collected in 1839 and inserted in the geological report for that year, regarding the produce of the lead mines situated in the upper magnesian limestone of the Mineral Point and Du Buque Districts of Northern Illinois, Dr. Owen has appended to the present report a table of the actual recorded shipments of lead from Galena from February to December, in the years 1841, 2, 3, 4, 5, 6 and 7, as furnished to him by Mr. James Carter, banker at Galena, Illinois. It is as follows:

Months.	Pigs lead, 1841.	Pigs lead, 1842.	Pigs lead, 1843.	Pigs lead, 1844.	Pigs lead, 1845.	Pigs lead, 1846.	Pigs lead, 1847.
February	.....	.....	.....	.....	5,287	.....	.....
March	4,080	80,125	.....	78,636	97,746	28,841	15,669
April	91,296	65,080	73,449	82,737	104,558	126,078	82,231
May	91,233	46,515	122,224	89,982	98,623	142,489	119,391
June	57,110	37,959	74,475	80,784	87,058	113,209	185,084
July	58,820	54,436	77,333	66,699	68,153	83,559	110,383
August	37,257	43,250	67,233	55,200	107,957	50,257	61,462
September	16,092	39,081	45,400	54,203	63,424	58,827	67,761
October	46,286	54,941	67,473	63,072	78,887	71,668	63,825
November	50,640	26,472	33,734	53,288	71,767	54,291	65,873
December	.....	.....	.....	.....	.....	1,500	.....
Total	452,814	447,859	561,321	624,601	778,460	730,714	771,679
First arrival of steamboats	March 22	March 9	April 10	March 5	Feb. 26	March 10	March 29
Last departure of steamboats	Nov'r. 22	Nov'r. 16	Nov'r. 26	Nov'r. 21	Nov'r. 23	Dec. 2	....

As a pig of lead will weigh, on an average, 70 pounds, it appears from the above table that the annual produce has varied, in the last seven years, from nearly thirty-two millions, to upwards of fifty-four millions of pounds.

‡ Literally, the Mountain which soaks in the water.

the strata gradually decline; so that at Red Rock the fossiliferous shell limestone and underlying incoherent white siliceous sandstone, which crowned the hills bordering on the lower Wisconsin river, and which soon ran out after passing Prairie du Chien, were again in place, forming the table land. Gradually increasing in thickness towards St. Paul's and Carver's Cave, these beds form there the entire mural ledges above the waters of the Mississippi and constitute the escarpment of Fort Snelling, as well as at the Falls of St. Anthony. Five or six miles above this, these and indeed all the protozoic strata, are seen for the last time in ascending the Mississippi, being lost under the drift deposits which cover all the rocky strata from view to the vicinity of the Sank Rapids where the granite protrudes.

In regard to the physical features of the celebrated country between the mouth of the St. Peter's and the Falls of St. Anthony, we extract the following:

"The Falls of St. Anthony are at present seven miles from the mouth of St. Peter's river. It is, however, more than probable that they once occupied a position at or near Fort Snelling. Of course, little evidence can be gathered of the rate of wearing, from actual observation of the inhabitants recently settled there, but, judging from the condition of the strata themselves, there must have been a rapid retrocession. The cement, which holds together the particles of the St. Peter's sandstone, is so slight that it is with difficulty a solid specimen can be obtained. Yet this is the rock, with a covering only of fifteen or twenty feet of schistose limestone, to protect it from the swift current of the Mississippi, which forms the base of the falls.

"The confused heaps of disjointed masses of limestone, piled together below the falls, indicate the undermining action in progress. The inclined position, too, of the ledges of limestone there, for several hundred yards above the chute, contrary to the local dip, has mostly been produced by the water which sweeps over them, entering the extensive rents which run across the strata at this place, and gradually washing out the particles of sand upon which these ledges repose, thus allowing them gradually to sink, and causing huge blocks to become, from time to time, detached and precipitated into the rapids beneath. In this way the fall will, probably, after a lapse of time, be converted into a rapid. For, in proportion as the fall shall recede, the sandstone, by reason of its dip, will diminish in thickness, and at length disappear beneath the river bed. From observations of the dip at the falls, this latter contingency will occur when the fall has been worn back some six or seven miles from its present position.

"There can be little doubt that the rate of erosion at the falls of St. Anthony must be more rapid than at the falls of Niagara, since the soft sandstone of the former locality is more easily washed away than the Niagara shale.

"On the brink of the gorge, near Fort Snelling, no fluviatile remains have been yet found at a height where the waters may be supposed to have flowed in former times; but Dr. Shumard, who was instructed to collect evidence of any ancient river deposits at a higher level, observed over the limestone at the falls a bed of drift of about eleven feet in thickness, and resting on that, a bed of sand containing species of *Cyclas*, *Limnæa*, *Physa* and *Planorbis*, and this deposit he traced on to the same level for nearly half a mile below the present position of the falls.

"The same gentleman also observed, half a mile below the falls, and about a quarter of a mile east of the gorge, on rising ground over which runs the trail to St. Paul's, a white marl charged with the same genera of shells, but of different species.

"The former of these deposits is doubtless of fluviatile origin, and affords evidence of the river having flowed, for a short distance at least above the gorge; the latter seems to be a lacustrine deposit, the bottom of some drained lake, of which there are numerous instances in the Chippewa land district.

"If we except these beds and the underlying drift, no formations of more recent date than the shell limestones of St. Peter's were observed along the Mississippi from the Wisconsin river to the Falls of St. Anthony. This statement will apply also to the country east of the Mississippi, as far as the water-shed between that stream and Lake Superior, except along the valley of the St. Croix above the falls."—pp. 31, 32.

The 2d Chapter contains a description of the geological formations of the Winnebago Reserve, a tract of country in Iowa lying between lat. 43° and 43° 30′, extending on the west side of the Mississippi as far as long. 93° 30′. Until the autumn of 1848 the Winnebago Indians occupied this neutral ground between the white settlements and the Sank and Foxes; when the former tribe were removed to the Two River country above the Sank Rapids.

The principal streams which water the Winnebago Reserve are: Turkey, Upper Iowa, and Red Cedar. It was along these streams that the examinations were chiefly directed.

We learn from the report that along that part of Turkey river which meanders near the southern line of this Reserve tract, fossiliferous limestones, of the same age as those above the second terrace at Prairie du Chien, form low ledges crested with cedars and surmounted by a green slope from which the upper magnesian limestone rises in fantastic shaped cliffs.

Ascending the same river to the Indian Agency and Fort Atkinson, the strata gradually rise. At the former locality, the elevated ground usually presents a mural cliff of from fifty to sixty feet high, resting on table land, the elevation of which above Turkey river is about one hundred and forty feet. Here and there are also isolated, mound-like hills, nearly flat on the top and so symmetrical in form that, were it not for their height and extent and their being composed in their interior of solid ledges of rock, one might be tempted to attribute to them an artificial origin.

The lower strata are more schistose, being chiefly marlites with alternations of calcareous layers. The most conspicuous fossils are: *Leptæna Madisoniensis*, *L. sericea*, *L. alternata*, *Orthis formosa*, *Pleurotomaria bilex*, and *Isotelus megistos*. Others less abundant, are: *Atrypa capax*, *A. exigua*, *Spirifer lynx*, *Trochus bilex*. Several trilobites probably of undescribed species allied to *Phecops;* one near to *P. calicephalus*, but with compound eyes. There was also obtained in this vicinity a specimen of *Bumastis barriensis* which was probably washed from higher ground.

The Upper Iowa for the last fifty miles of its course, flows between cliffs of lower magnesian limestone based on the lower sandstones, which latter, with an interlamination of magnesian limestone towards its upper part, constitutes the greater part of the rock exposure near the confluence of that stream with the Mississippi.

There are many fine examples on this river of those remarkable castellated forms which the lower as well as upper magnesian limestone often assumes. Several sketches illustrating the features of the country, accompany the report.

On the Upper Iowa, about longitude 91° 50′, the following fossils were found in the lower 150 feet of rock: *Leptæna sericea*, *Leptæna rugosa*, *L. Madisoniensis*, *L. deltoidea*, *L. alternata*, *Pleurotomaria lenticularis*, *Cyathophyllum ceratites*, *Coscinopora sulcata*, *Bellerophon bilobatus*, *Isotelus megistos*, *Orthis testudinaria?* *O. formosa*, *Illænus crassicauda*, *Murchisonia bellicincta*, *M. subfusiformis*, *Atrypa capax*, *Orthis subæquata*, *Atrypa hemiplicata*, *Orbitulites? reticulatus?*

In this part of the Reserve the formation is evidently of the same age as that near the Agency on Turkey river, which lies about twenty miles to the south. Both appear to represent the Trenton limestone and Hudson river group of New York, and to be cotemporaneous with the Lower Silurian system of England.

Regarding the formation of the western portion of the Reserve along the Red Cedar river we extract the following:

"On Red Cedar there is a change in the geological formation of the country. Either this is the western limit of the formations of Upper Iowa and Turkey rivers, or else the southwest dip carries the formations before reaching the Red Cedar beneath the water courses; for on crossing the Red Cedar, the first ledges that came under my observation, only a few hundred yards to the west of it, were found to be charged with the large variety of *Atrypa prisca* and a *Spirifer*, very abundant in the shell beds of the falls of the Ohio, and allied to the *S. ostiolata* of the Devonian system of the *Eifel*, if not identical with it. These strata appear to be the equivalent of the rocks described in my report of 1839, as occurring lower down on the same stream in the Dubuque district, so that the line of bearing between these two formations, Silurian and Devonian, seems to run nearly parallel with that stream.

"The Red Cedar limestone extends up its west branch as far as I penetrated, i. e., to near the north line of the Winnebago Reserve; it also stretches away to the west as far as the limits of my observations, viz.: to Willow river. On Shell Rock, the east branch of Otter, I found in it, besides *Atrypa prisca*, casts of *Lucina proavia*, and an undetermined species of *Leptæna*. But the fossil which is most abundant, and most universally distributed through the rocks of this western portion of the Winnebago Reserve, is a very fine structured coral, composed of concentric layers, like the genus *Stromatopora*, but so close together that the layers can only be distinguished by close inspection with a magnifier. On Lime river, the west branch of the Otter, the strata are so full of this close grained coral that it might with propriety be called a coralloid limestone.

"Some of the beds of this formation consist of very close textured and smooth calcareous beds, like the lithographic limestones, splitting with a flat conchoidal fracture. In it I did not observe any fossils; but I had not many opportunities of examining exposures either of it, or, indeed, of any of the other members of the formation in question, along the line of my route. The geologist who undertakes to investigate the vast prairie countries of the Mississippi valley must be provided with no common share of patience and perseverance. He must be content to travel for half a day together without seeing aught but a rich black soil, covered, as far as the eye can reach, even down to the very edge of the small streams, with a thick and high growth of prairie grass, with, perhaps, a faint outline of timber cutting the distant horizon. He must be prepared to wade swamps, to ford streams waist deep, or, in times of freshets, to plunge in and breast the current. He must not shrink beneath a broiling sun, without even a bush to cast a faint shadow over an occasional resting place. He must think himself fortunate, if he can reach, at night, a few scattered oaks to plenish his fire, and boil his camp-kettle; and he may consider it a special instance of good luck, if, in return, he can catch a glimpse of a rock exposure once or twice a day. He may travel for days together without lighting on any object more interesting than the hillock of the prairie dog, or the broad lair of the bison."—pp. 36, 37.

The western portion of the Reserve is said to present no indication of being a mineral country. Some portions of the Turkey river and Upper Iowa country afford a little lead ore.

The third chapter of the report is devoted to a description of the formations of the interior of the Chippewa Land District. In our notice of it we must be brief.

The protozoic strata which have been described as forming the sections on the Mississippi, extend on the east side of the Mississippi for an average distance in a direct line into the interior of fifty to seventy-five miles; that is, to the falls of the principal eastern tributaries of that river. Here the crystalline rocks first appear above the water courses forming low falls and rapids. These igneous ranges do not rise abruptly in this part of the United States into elevated mountains; on the contrary they are seldom seen except in the immediate cuts of the streams, being covered for the most part with drift. The character of the country generally towards the summit levels leading to Lake Superior, is a succession of terraces of moderate elevation, chiefly composed of drift, often having a nucleus no doubt of granite, syenite or hornblende rocks; but these protrude only occasionally. At intervals the streams are ruffled into rapids, being filled with boulders which obstruct materially their navigation. A portion of these boulders may have been transported from great distances; the greater part however appear to be not far removed from the parent rock.

It is matter of surprise that so large an area of the interior of this district, and indeed of the sources of the Mississippi generally, should be level tamarack and cedar swamps, since in approaching a great water shed that gives rise to one of the largest rivers in the world, one is led to anticipate a country with physical features of quite a different character.

Interposed between the crystalline and igneous rocks of the interior of the district and the lowest sandstones, some green and red schistose beds have been observed at different localities. These appear to have been derived from the decomposition and detritus of the more easily decomposing felspathic granites.

The lower beds of sandstone adjacent to the igneous outburst, are not unfrequently changed to a hard quartzite. The red pipestone so highly prized by the northern tribes of Indians, is found also near the junctions of these formations, associated with quartzite.

We learn from the 4th chapter of the report that, except in the valley of the St. Croix, the red sandstones, marlites, slates, conglomerates and associate trap ranges which prevail in the district along the south shore of Lake Superior, extend only as far as the elevated ridges, whence rise the tributaries of the Mississippi on the one hand and the streams emptying into Lake Superior on the other. Over a large portion of this area the solid rocky beds are covered by comparatively recent deposits of drift sand, red marls and red clay; the latter derived apparently from the disintegration of the strata on which they repose; and have been produced by oscillations of the surface during the more recent periods of uplifts.

At various points along the range of outburst of the igneous rocks, mineral veins have been observed. The examinations had not been sufficiently minute to pronounce on their productiveness. The hypogene rocks observed by the Wisconsin corps through this region of country are: granites, syenite, hornblendic rocks, greenstone, and various kinds of trap.

The highest ridges of the south shore of Lake Superior, situated in the Chippewa Land District, are represented as formed of hornblende rocks, metamorphic slates, syenite and trap. These are estimated to be over a thousand feet above the lake, and are situated from ten to sixteen miles from its shore.

No organic remains had so far been found in the formations of Lake Superior by which to establish their age. Neither had any localities been discovered, where beds of known geological position might solve the question by indicating the relative order of superposition.

The principal mass of sandstone constituting the south shore and west end of Lake Superior in Wisconsin, appears to have a different lithological character from the sandstones beneath the lower magnesian limestone on the Mississippi, described in the 1st chapter of the report. So far as this evidence can be depended on, it militates against the supposition of their geological parallelism.

On the west side of the Mississippi, north of the Winnebago Reserve, as far as the St. Peter's river, the lower magnesian limestone and underlying sandstones prevail as far as the examinations had extended, i. e., for about half a degree of longitude. The former of these formations occupies the greatest area.

ART. II.—*On Rutilated Quartz Crystals from Vermont, and Phenomena connected with them;* by FRANCIS ALGER, A.M., Member of the American Academy, and of the Society of Natural History, Boston.

(From the Proceedings of the American Association for the Advancement of Science, held in Cambridge, in August, 1849.)

Mr. ALGER presented a paper on the quartz crystals from Waterbury, Vermont, containing acicular or capillary Rutile, and exhibited illustrative specimens of great perfection and beauty. He compared them with other specimens from the Alps and Brazil, and pointed out some important phenomena in which they differed from those, and all other rock crystals he had seen.

Erratic masses of rutilated quartz had, from time to time, been found in Waterbury, and several of the neighboring towns, and they had even been picked up in New Hampshire; but their geological association, or the character of the rock from which they originated, had not been well understood until recently. Mr. Alger had lately visited a remarkable locality of this mineral, where a true vein, two feet or more in width, had been brought to light in making a deep cut through a hill in Waterbury, on the line of the Vermont Central Railroad. The rock is a very tenacious talcose slate, sometimes passing into mica slate, and prevails to a great extent in this part of Vermont. Metalliferous veins are rarely contained in it, but veins of quartz are common. The vein here referred to, consisted principally of common amorphous quartz, presenting internal cavities or druses, lined or studded with projecting prismatic crystals, sometimes colorless and transparent, but more frequently of a smoky color, or brownish yellow tint, (Cairngorm.) The pure glassy white crystals, are but rarely penetrated by the acicular rutile, while the colored varieties abound with it, and seem in fact to owe the intensity of their color to the very prevalence of it through their substance.

The rutile is sometimes grouped in tufts of radiating crystals, proceeding from a common point, and shooting through the quartz; this being also the ordinary manner of its occurrence in the Brazilian specimens. The direction of many of these diffused crystals in the position they now occupy, would seem to show that they had been subjected to some electrical or polarizing influence, by which they had been arranged very nearly in a line parallel with that of the apex or perpendicular axis of the crystals of quartz in which they are imbedded. It would seem that they were once floating, as it were, in the transparent and liquid medium of the silicious mass; or else, what is more probable, in the simultaneous crystallization of both quartz and rutile, slowly or otherwise, there was superadded a polarizing influence which caused them to converge towards one point. Or again, it may be that these peculiarities are confined to those quartz crystals which projected downwards in the cavity of the vein at the time of their formation; and thus the rutile, from its greater specific gravity, would have a tendency to crystallize and extend itself downwards, rather than in any other direction. Mr. Alger could not state from actual observation at the locality, whether such was the fact.* The appearance referred to is most marked in those crystals in which the rutile exists in the most delicate hair-like and needle-shaped forms, (*Venus hairstone;*) and, in some instances, these delicate prisms are bent towards the ends most remote from the apex of the quartz crystals. They are sometimes four inches in length.* By transmitted light, their color is reddish brown; lustre like that of polished copper. Some few of the needles are entirely black, and closely resemble schorl. It was the opinion of Mr. Kennedy, a scientific engineer, and a very close observer, who was present at the opening of the vein, that the crystals of quartz enclosing rutile, were confined to one side only of the vein, thus indicating two periods in its formation, in one of which no rutile was present to intercrystallize with the mass. All the recently obtained crystals are very much discolored by iron rust, and the vein appears to be "run out." But its loss will undoubtedly be soon supplied by other sources.

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* That mineral veins may owe their origin in many cases to electrical or electro-chemical agencies, has been shown by the experiments of Fox, Becquerel and others, who by ingenious contrivances imitating the conditions which were supposed to exist in nature, have produced precisely similar results, even the formation of various crystallized bodies; but the subject has not been pursued with that direct application to the origin and structure of crystals, in their natural repositories, which it deserves. "Future investigations, (as has been said by Dana,) with regard to the position of crystals in rock strata, especially in granite and allied rocks, may prove that the electric currents in constant circulation around the earth have been active agents in determining the direction in which the axes of crystals lie, and the course of cleavage planes." Dana's Mineralogy, second edition, p. 88.

Prof. Hubbard, of Dartmouth College, in whose possession is the finest specimen of this mineral found in the United States, first noticed a most interesting fact in regard to these crystals, namely, that the needles of rutile in some cases, had shot completely through the quartz crystals, and stood out in relief upon their surfaces, as if protruded by the sudden effort of their crystallization. The same appearances were presented to a small extent, by one of Mr. Alger's specimens. If produced in the manner supposed, the quartz must have been in a liquid state; if not produced in that manner, the crystallization of the rutile must have continued after that of the quartz had ceased. The latter seems the most reasonable supposition, and is favored by analogous phenomena in other crystallized minerals.

Imitative forms of mica contained in the Quartz.—The surfaces of two of the large crystals exhibited by Mr. Alger, as well as several smaller fragments of crystals, were covered by minute but very brilliant scales of gold-colored mica; and these sometimes penetrated the quartz in company with the rutile, and, in the same manner, seemed confined mostly to the darkest colored varieties of the quartz. But the appearance presented by this mica, is curious and altogether unique, for in the substance of the crystals, it has assumed the most fantastic forms, appearing in tortuous and vermicular ramifications, some of them bearing such a striking resemblance to organized bodies, as to give the first impression that they are actually the remains of insects or worms. The figures on the next page present a correct representation in a magnified form, of some of the most curious of these appearances exhibited by Mr. Alger's specimens. He had dissected out several of them, and found them to be composed entirely of small plates of mica more or less closely united parallel with the cleavage

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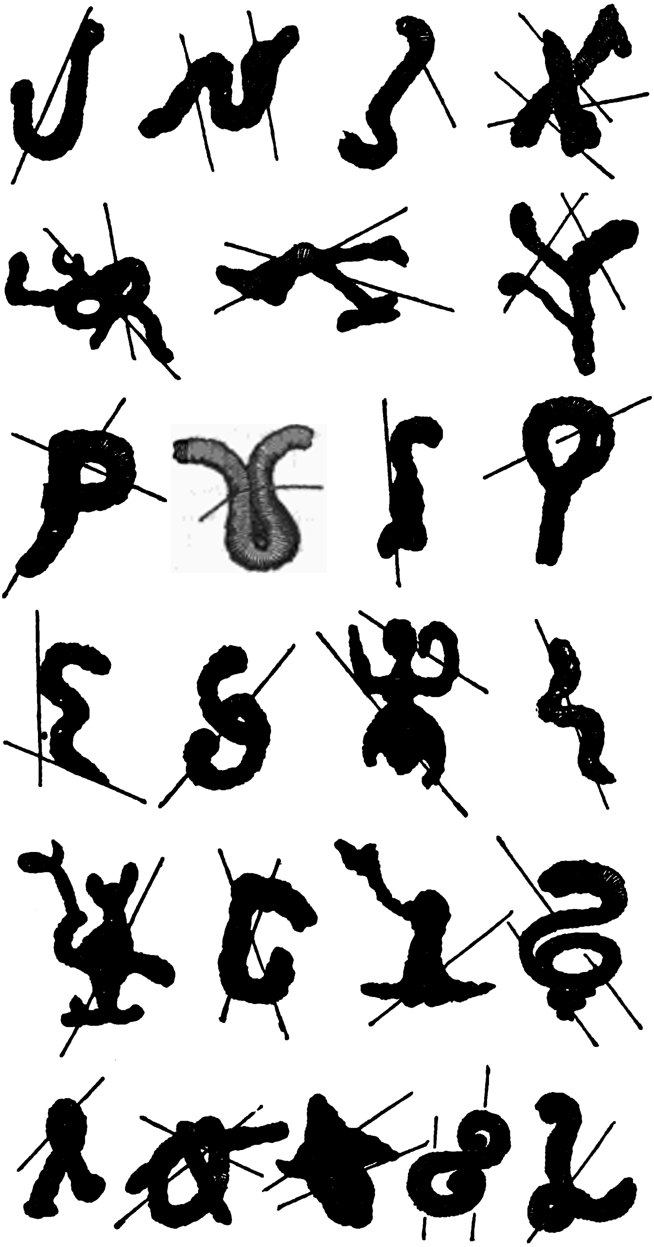
* The polished specimens in which these prisms are exhibited, (known in French jewelry as *Flèches d'amour,*) are rarely surpassed in beauty by the finest to be met with in foreign collections. The reticulated forms are thus shown in great perfection.

1.



planes of the mineral. In fact, they are elongated hexagonal crystals of mica, twisted or distorted into every imaginable shape. Their laminated micaceous structure is shown perfectly by the microscope, and is represented by the transverse lines in the figures. The resemblance of the third figure on the fourth row, to some species of Araneides, is not too remote to suggest them instantly to the mind; and the general resemblance of several of the figures to the blood leech and common worms is still more striking—these being produced by the successively diminishing diameters of the little plates of mica until they terminate nearly in a point. But the origin of these resemblances was evidently fortuitous, and could not have been in any way connected with organic matter. They are interesting principally as furnishing a new fact in the department of imitative mineralogy, and they appropriately suggest the term vermiform mica as most characteristic of their general appearance. Vermiform should therefore be included among the imitative shapes assumed by minerals. The striking resemblance between several of these figures and the worm-like projections thrown out by the separating folia of *vermiculite* when exposed to a red heat, will occur to every one who has experimented on the mineral. The following examples of them were obtained by heating a fragment of the pure mineral broken from a specimen lately analyzed in Dr. Jackson's Laboratory. They are of natural size.

2.

The straight lines seen passing through several of these figures, are intended to show the needles of rutile that actually intersect these concretions of mica in the body of the stone. In some of them the rutile passes through the circular space left by the folding over of the mica, and its crystallization does not seem to be interrupted by the mica in any case. A characteristic feature of rutile, but never shown in any of the specimens from this locality, (i. e., the geniculated forms,) seems to be imitated by the mica, and is best shown by the second figure in the lower row.* The color of this mica by transmitted light, is a pale green, and the mineral seems to agree in external characters with the substance from other localities. Considerable quantity of it was found loose in the vein, mixed with broken crystals of rutile.† The only appearances at all analogous to those just described, which had come to the knowledge of Mr. Alger, were those mentioned and figured by Dr. McCulloch, and described in vol. ii, of the Geological Transactions of London. But in this case, the substance was chalcedony, and the imbedded masses composed of chlorite, had nothing of a crystalline structure, and in fact were rather imitative of vegetable, arborescent forms.

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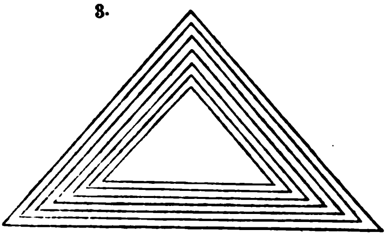
* Prof. Hubbard's specimen presented the appearance in so marked a manner, as to lead to the impression that they were rutile.

† A portion of this carefully separated, was found to lose nearly 15 per cent. of water when heated to the melting point of glass. A peculiar empyreumatic odor was at the same time given out, but there was no reaction of fluorine. Exposed in a platinum crucible to a white heat for twenty minutes, it became grayish black and partially fused into a mass. In this state it was slightly magnetic. The large proportion of water seems to ally it with pennine, or perhaps with hydro-mica from the Alps— *Wasserglimmer* of M. Morin;—while its crystalline form, an oblique rhombic prism changed into a six-sided figure by the truncation of its acute lateral edges, refers it at once to common mica.

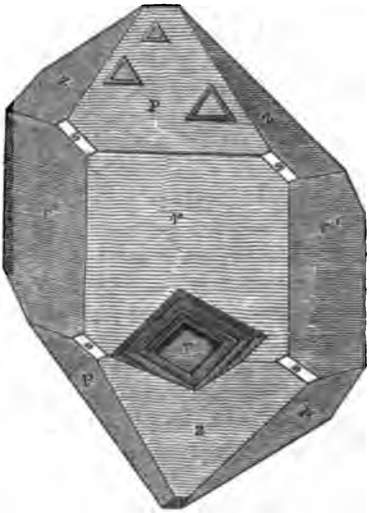
3.



STRIATED QUARTZ CRYSTALS.

The annexed figure represents some of the striæ which appear on the acuminating planes of the crystals, and are parallel with their edges of combination with the adjoining planes, as shown in the figure below. They are usually mere superficial triangular lines so slightly impressed as to be visible only when held in a particular position in regard to the light; but in a few cases, these configurations, commencing at a small point before the crystal had attained its full size, continue to widen with every fresh layer of particles deposited upon the faces of the crystal, until they produce cavities of considerable depth. That they were formed in this manner, is indicated by the step-like appearance of the sides of these cavities—an appearance which is more strikingly presented in a few cavities of a different shape, of one of which the annexed figure furnishes an example. In this, it will be noticed, the cavity is rhomboidal, and might at first be mistaken for the impression left by some foreign substance which had disappeared. No substance having such form, has been found attached to any of the crystals from this place, and although the angles at which the sides meet each other, (about 72° and 108°,)* are nearly those of calc spar, or carbonate of iron, it is evident from the enlargement of the cavity towards the surface of the crystal, or the hopper-like appearance assumed by it, that neither

4.



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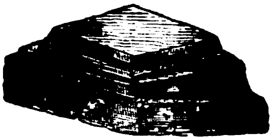
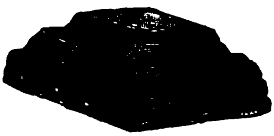
* These angles were incorrectly given in the published Proceedings of the American Association. They have now been obtained by measuring the casts taken from its cavity, instead of the cavity itself.

of these substances could have produced it. The quartz, while depositing itself around either of them, would have taken the exact form of either, precisely as we see such impress of their forms in other crystals of subsequent formation, as for example, in the quartz crystals from Herkimer, New York. So it is evident, that if any substance ever occupied the cavity, it must have received its form from the cavity, without communicating any to it; and thus a pseudomorphous crystal may have been produced in a manner somewhat different from usual: viz., by filling up a cavity which had never been occupied by any crystallized substance whatever. Should such pseudo-crystals of infiltration or deposition, be met with in similar cavities of the quartz from this locality, it will become an interesting enquiry to determine whether they have the same composition, or are various depending upon accidental circumstances. If the view here taken of them be correct, they cannot come under the designation of any of the pseudomorphs hitherto described, (as they do not assume the form of any other crystal which has disappeared,) and we must accept such explanation of them as is afforded by the quartz itself. It is not easy to trace in these cavities, as it is in those before spoken of, any certain relation between them and the crystalline structure of the quartz whose surfaces they impress; their sides are not parallel with any of the striæ as seen upon the faces of the crystals; they indicate an interruption in the process of crystallization, and we have only to suppose a successive retrocession or withdrawal of particles in such parallel directions, thus enlarging the cavity outwardly, as the crystal itself increased in size. They do not appear to have been produced by the irregular combination of two or more crystals or by the union of different crystalline planes leaving spaces between them, because the striations which mark the faces of the crystal, and which have been intercepted by the cavity, appear opposite to each other on both sides of the cavity. This is shown by the figure. It therefore appears to belong to one crystal. The cavity intended to be represented by the large figure measures one inch on a side, and half an inch in depth; the striations at bottom are parallel with those upon the face of the crystal. It is more accurately shown by the following drawings taken from a cast of it in wax, which presents it in opposite positions.* The crystal itself, has a rhom-

5.



6.



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* The deep bevelment on the broadest surface of these casts, (not shown in the cuts,) gives the true angle at which the plane r of the crystal (see fig. 4) meets plane s—the cavity extending partly into one of the planes of the pyramid.

boidal plane on each of the adjacent lateral angles of the prism, and not as is usual, on the alternate angles. It is permeated in every part by acicular rutile. This rutile, in one or two instances, has shot through similar cavities in other crystals, its delicate hair-like needles remaining unbroken while their opposite extremities are deeply imbedded in the quartz. In one of these cavities the depth is more than twice that of the transverse diameter, but the same step-like succession of layers is observed as in the large one, diminishing in their descending order, until they nearly terminate in a point towards the centre of the crystal. Compared with the large cavity, there is greater evenness of outline in these little ridges, and a nearer approach to parallelism between them.

ART. III.—*Examination of Kirkwood's Analogy;* by SEARS C. WALKER.

(From the Proceedings of the American Association, 2nd meeting, held at Cambridge, 1849, p. 212.)

IN order that Kirkwood's Analogy should apply to all the planets of the Solar System, including the interpolated planet between Mars and Jupiter, four fundamental conditions must prevail for each planet considered as the middle of a consecutive series of five; namely:

$$\text{I.} \ldots\ldots\ a=\frac{(a_{,}+b_{,})c_{,}+(a'-b')c'}{c_{,}+c'}$$

$$\text{II.} \ldots\ldots\ m=[(a-a_{,}-b_{,})c_{,}]^{2}$$

$$\text{III.} \ldots\ldots\ m=[(a'-a-b')c']^{2}$$

$$\text{IV.} \ldots\ldots\ \theta=\frac{2\pi}{\varkappa}\cdot\alpha^{\frac{3}{2}}$$

Where

$a_{,,,}$ $a_{,,}$ a, a', a'' = the five mean distances of the planets.

m = the mass in parts of the sun's mass similarly accented.

T = the sidereal year, in earth's mean solar days.

θ = the sidereal rotation in the same.

k = Gauss's *revolution constant* from Kepler's third Law.

$\varkappa$ = a similar *rotation constant* from Kirkwood's Analogy.

$r_{,}$ = the inner radius of the sphere of attraction for the third planet.

r' = the outer radius of the sphere of attraction for the third planet.

$r_{,,}$ = the outer radius of the sphere of attraction for the second planet.

r'' = the inner radius of the sphere of attraction for the fourth planet.

$D = r_{,} + r'$ = Kirkwood's diameter of the third planet's sphere of attraction.

$$\alpha = \frac{a}{D}$$

From these definitions the value of D is thus derived:

$$\frac{m_{,}}{r_{,,}^{2}} = \frac{m}{r_{,}^{2}}$$

$$\frac{m}{r'^{2}} = \frac{m'}{r''^{2}}$$

$$r_{,,} = a - a_{,} - r_{,}$$

$$r'' = a' - a - r'$$

$$\frac{m}{r_{,}^{2}} = \frac{m_{,}}{(a - a_{,} - r_{,})}$$

$$\frac{m}{r'^{2}} = \frac{m'}{(a' - a - r')}$$

$$r_{,} \sqrt{m_{,}} = (a - a_{,} - r_{,}) \sqrt{m}$$

$$r' \sqrt{m'} = (a' - a - r') \sqrt{m}$$

$$r_{,} = \sqrt{m} \left(\frac{a - a_{,}}{\sqrt{m} + \sqrt{m_{,}}} \right)$$

$$r' = \sqrt{m} \left(\frac{a' - a}{\sqrt{m'} + \sqrt{m}} \right)$$

$$D = (r_{,} + r')$$

$$= \sqrt{m} \left(\frac{a - a_{,}}{\sqrt{m} + \sqrt{m_{,}}} + \frac{a' - a}{\sqrt{m'} + \sqrt{m}} \right)$$

$$= \left(\frac{2\pi}{x} \right)^{\frac{2}{3}} \cdot \left(\frac{1}{\theta} \right)^{\frac{2}{3}} \cdot a$$

$$b_{,} = \left(\frac{2\pi}{x} \right)^{\frac{2}{3}} \cdot \left(\frac{1}{\theta_{,}} \right)^{\frac{2}{3}} \cdot a_{,} - \sqrt{m_{,}} \left(\frac{a_{,} - a_{,,}}{\sqrt{m_{,}} + \sqrt{m_{,,}}} \right)$$

$$b' = \left(\frac{2\pi}{x} \right)^{\frac{2}{3}} \cdot \left(\frac{1}{\theta'} \right)^{\frac{2}{3}} \cdot a' - \sqrt{m'} \left(\frac{a'' - a'}{\sqrt{m''} + \sqrt{m'}} \right)$$

$$c_{,} = \frac{\sqrt{m_{,}}}{b_{,}}$$

$$c' = \frac{\sqrt{m'}}{b'}$$

$$b_{,} = \sqrt{m_{,}} \left(\frac{a - a_{,}}{\sqrt{m} + \sqrt{m_{,}}} \right)$$

$$b' = \sqrt{m'} \left(\frac{a' - a}{\sqrt{m'} + \sqrt{m}} \right)$$

$$\sqrt{m}+\sqrt{m_{,}}=(a-a_{,})c_{,}$$
$$\sqrt{m'}+\sqrt{m}=(a'-a)c'$$
$$m=[\,(a-a_{,}-b_{,})c_{,}]^2$$
$$m=[\,(a'-a-b')c']^2$$
$$a=\frac{(a_{,}+b_{,})c_{,}+(a'-b')c'}{c_{,}+c'}$$

Computation of the Value of the Constant called $\varkappa$.

If we use Leverrier's* mean distances and masses in his theory of Mercury, with the exception of Adams's† value $\frac{1}{21000}$. for the mass of Uranus, and Hansen's‡ periods of rotation, we find by condition (IV.) the following values of

$$\varkappa=\frac{2\pi}{\theta}\cdot a^{\frac{3}{2}}$$

Namely:

$\varkappa=15.179$ by Venus.
$=14.811$ by Earth.
$=15.593$ by Saturn.

Whence, with double weight for Saturn:

$\varkappa=15.300=$ mean value adopted.

If we form another constant $k'=\left(\frac{\varkappa}{2\pi}\right)^{\frac{2}{3}}$ we find

By Venus, $k'=1.9377$
Earth, $=1.9054$
Saturn, $=1.9772$

From which it appears that an approximate value for the rotation times might be obtained from

$$\theta=\left(\frac{a}{2D}\right)^{\frac{3}{2}}$$

But the other formula is preferable; and we have

$$\theta=\frac{2\pi}{\varkappa}\cdot a^{\frac{3}{2}}=\frac{2\pi}{15.3}\cdot a^{\frac{3}{2}}=\frac{\pi}{7.65}\cdot a^{\frac{3}{2}}$$

With this value of $\varkappa$, using the data above mentioned, interpolating the a, m, and θ of the fifth or hypothetical planet, called Kirkwood, and three masses, viz.: of Mercury, Mars, and Uranus, the following normal elements of the primary system are obtained, in which all of the above four fundamental conditions are fulfilled for each middle planet of five. For Neptune, Mr. W. had used his own value of the mean distance, and Prof. Peirce's mass from Bond's measures of the elongation of the satellite. The interpolated values are enclosed in parentheses.

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* Additions à la Connoissance des Temps, 1848, 17–26.
† Proceedings R. A. Soc., vol. ix, pp. 159, 160.
‡ Schumacher's Jahrbuch, 1837.

Table of Planetary Elements, conforming rigorously with Kirkwood's Analogy.

Planet.	Mean distance.	Mass in parts of the sun's mass.	Sidereal revolution in earth's mean solar days.	Diameter of the sphere of attraction.
	a	m	θ	D
Mercury*	0.387.099	$\left(\frac{\dagger\,1}{2802311}\right)$	1.003.473	(0.198.122)
Venus	0.723.333	$\frac{1}{401847}$	0.972.917	0.377.908
Earth	1.000.000	$\frac{1}{\ddagger\,354936}$	0.997.270	0.513.934
Mars	1.523.691	$\left(\frac{1}{2107404}\right)$	1.025.936	0.768.429
Kirkwood	(2.908.511)	$\left(\frac{1}{1353240}\right)$	(2.406.104)	(0.830.951)
Jupiter	5.202.800	$\frac{1}{1050}$	0.385.907	5.035.373
Saturn	9.538.852	$\frac{1}{\S\,3512}$	0.437.003	8.497.477
Uranus	19.182.730	$\left(\frac{1}{23733}\right)$	(1.396.779)	(7.875.342)
Neptune	30.039.500	$\frac{1}{20000}$		

* An interpolated planet with a mean distance $a=0.20$ and a mass of $\frac{1}{4739670}$, would harmonize with the above system.

† This interpolated mass of Mercury compares with observation thus:—

Leverrier's first mass, ... $\frac{1}{1.909.700}$
Walker's interpolated mass, . . $\frac{1}{2.802.311}$
Leverrier's second mass, . . . $\frac{1}{3.000.000}$
Encke's value, ... $\frac{1}{4.865.771}$

‡ And for Mars:

Burckhardt's mass, ... $=\frac{1}{2.680.637}$
Walker's interpolated do, . . $=\frac{1}{2.107.404}$

§ And for Uranus:

Adams's mass, ... $\frac{1}{21000}$
Walker's interpolated mass, . . $\frac{1}{23733}$
Lamont's mass, ... $\frac{1}{24605}$
Struve's mass, ... $\frac{1}{26860}$

Conclusions from the above table.

From this comparison of authorities, it appears that with a constant value of $\varkappa = 15.300$, and with assumed masses of Mercury, Mars, and Uranus, equally plausible with those heretofore employed, the a, m, and θ, of the fifth or hypothetical planet may be thus interpolated:

$$^{*}\, a = 2.908.511$$

$$m = \frac{1}{1.353.240}$$

$$\theta = 2.239.035$$

And then the system of nine values of a, m, and θ, will be normal with reference to Kirkwood's analogy, and each of the four fundamental conditions (I.) (II.) (III.) and (IV.) will be rigorously fulfilled for every middle planet of five.

Mr. Kirkwood had remarked in his letter,† that his analogy required the assumption of a fifth planet between Mars and Jupiter. If the Geological Section was allowed the privilege of restoring fishes, lizards, and elephants, there was no reason why the Physical Section should not be permitted to restore a planet.

Remarks on the Degree of Constancy of $\varkappa$.

The limits within which it is possible to vary the value of $\varkappa$, without making some of the interpolated elements inadmissible, are about one-twentieth of the adopted mean value of 15.300. We may therefore conclude that, WHETHER KIRKWOOD'S ANALOGY IS OR IS NOT THE EXPRESSION OF A PHYSICAL LAW, IT IS AT LEAST THAT OF A PHYSICAL FACT IN THE MECHANISM OF THE UNIVERSE. The quantity D, on which the analogy is based, has such immediate dependence upon the nebular hypothesis, that it lends strength to the latter, and gives new plausibility to the presumption that this, also, is a fact in the past history of the solar system.

Such, then, is the present state of the question. Thirty-six elements of nine planets, (four being hypothetical,) appear to harmonize with Kirkwood's analogy in all the four fundamental equations of condition for each planet.

To suppose that so many independent variable quantities should harmonize together by accident, is a more strained construction of the premises than the frank admission that they follow a law of nature.

If, in the course of time, the hypotheses of La Place and Kirkwood shall be found to be laws of nature, they will throw new light on the internal organization of the planets, in their present, and in any more primitive state, through which they may have passed.

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* The mean distance is greater than that of the asteroids, except Hygeia, which has $a = 3.18$.

† This Journal [2], ix, 395.

For instance, we may compute the distance p, from the centre, at which any planet must have received its projectile force, in order to produce at the same time its double movement of translation and rotation. Now let $v=$ the planet's present angular rotatory velocity. Then, $K=pmv$, will be a constant quantity denoting its momentum of rotation.

If the planet, in a more primitive state, existed in the form of a ring revolving round the sun, having its present orbit for that of the centre of gravity of the ring, the momentum K of rotation must, by virtue of the principle of conservation of movement, have existed in some form in the ring. It is easy to perceive that this momentum K is precisely the amount which must be distributed among the particles of the ring, in order to preserve to all the condition of dynamical equilibrium, while those of each generating surface of the ring were wheeling round with the same angular velocity. It is also clear that this mean angular velocity must be that of the primary planet in its orbit, and accenting the quantities p and v for the case of the ring, we have the equations,

$$K=pmv=p'mv'$$

$$\frac{p'}{p}=\frac{v}{v'}=\frac{T}{\theta}\frac{\kappa}{k}D^{\frac{3}{2}}$$

$$p'=\frac{\kappa}{k}.D^{\frac{3}{2}}.p$$

But on the hypothesis that the law of decrease of density from centre to surface in the primitive shape was the same as at present,

Let $r=$ the present radius of the planet;

$R=$ that of the generating figure of the primitive ring;

Then, $\frac{p'}{p}=\frac{R}{r}$

And, $R=\frac{\kappa}{k}.D^{\frac{3}{2}}.r$

The value of R from this formula, comes out a very small fraction of D for the small planets, and nearly equal to D in the case of Jupiter, Uranus, and Saturn. If any inference can be drawn from this result, it is unfavorable to the hypothesis that the primitive law of decrease of density was the same as the present.

If the planets have really passed from the shape of a revolving ring to their present state, the prevalence of Kirkwood's analogy shows a nice adaptation of parts in every stage of the transition.

If the primitive quantity of caloric (free and latent) had undergone a very great change beyond that now indicated in the cooling of their crusts; if the primitive quantity of movement of rotation had been different from its actual value for any planet; if the law of elasticity of particles for a given temperature and distance from each other varied from one planet to another in the primitive or present states; in either of these cases, the analogy of Kirkwood might have failed. As it is, no such failure is noticed; we are authorized, therefore, to conclude, that the primitive quantity of caloric,—the law of elasticity,—the quantity of movement of rotation,—the past and present radii of percussion,—the primitive diameter of the generating surface of the rings, and the present dimensions and density of the planets, have been regulated by a general law, which has fulfilled for all of them the four fundamental conditions of Kirkwood's hypothesis.

After Mr. Walker had concluded, Mr. George P. Bond inquired of Mr. W. as to the applicability of his remarks on primary rings to the case of the secondary ring in the system of Saturn.

Mr. W. replied, that in the case of the breaking up of a primary ring, the day of the new planet would be equal to the year of the ring, provided the new diameter was the same as that of the generating figure, and the same law of decrease of density from centre to surface was preserved. In this case we should have

$$K=rmv=r'mv'$$

$$v=v'$$

and therefore $$p=p'$$

Such, however, is not the case in fact with the primary planets. The new diameter is contracted by the more immediate action of the central mass, more than it is expanded by the increase of free caloric. The new diameter is, therefore, so much smaller than the primitive D, that p' is changed into p, and v', or the yearly mean angular velocity, is changed into v for the daily value.

We may extend the nebular hypothesis, and Kirkwood's analogy to the secondary systems. If they are laws of nature, they must apply to both. In the secondary systems the day and month are the same. This fact has remained hitherto unexplained. Lagrange showed that if these values were once nearly equal, a libration sets in round a state of perfect equality; but he offered no conjecture as to the cause of the primitive equality. On the nebular and Kirkwood's hypothesis, it would only be necessary that upon the breaking up of the ring, the primitive diameter of the generating figure and law of relative density of layers, should be preserved, in order to maintain a constant value of $p=p'$, and consequently of $v=v'$.

Prof. Henry has shown that the moon, and probably the other satellites, by excess of radiation above absorption, have reached their constant minimum amount of free and latent caloric.

Perhaps this is the very condition required to maintain $p=p'$, and consequently $v=v'$. In this case we may conclude that p had exceeded p' immediately after the breaking of the ring, and only arrived at a state of equality by the loss of caloric from radiation.

Prof. Peirce remarked that Kirkwood's analogy was the only discovery of the kind since Kepler's time, that approached near to the character of his three physical laws. Bode's law, so called, was at best only an imperfect analogy. Kirkwood's analogy was more comprehensive and more in harmony with the known elements of the system. The diameter of the sphere of attraction, a fundamental element in this analogy, now for the first time gave an appearance of reality to Laplace's nebular hypothesis, which it never had before. The positive testimony in its favor would now outweigh the former negative evidence in the case, however strong it may have been. It follows at least from Kirkwood's analogy, that the planets were dependent upon each other, and therefore connected together in their origin, whatever may have been the form of the connection, whether that of the nebular hypothesis, or some other not yet imagined.

ART. IV.—*On Kirkwood's Analogy;* by Dr. B. A. GOULD, Jr.

(From the Proceedings of the American Association, 2nd meeting, held at Cambridge, 1849, p. 363.)

THE subject which Mr. Walker brought to the notice of this Section on Saturday, is one of far more than ordinary interest. Besides the elegant simplicity of Mr. Kirkwood's formula, his theory must, if it be confirmed, materially influence our views of cosmogony and of the theory of the Universe. I have devoted all of the time which my duties have allowed since Mr. Walker made his communication, to the numerical examination of the Analogy to which he referred and which prompted his beautiful investigations. I will state the results, though not in the fullness which they deserve, and with which I at first hoped to be able to give them; for although the subject is large, and one which we cannot expect to exhaust for many years, yet the time of the Section is so precious at this late hour, that I shall limit myself to as brief a statement as possible.

Mr. Kirkwood's theory, as regards the rotation of the planets will, if found to be true,—and the presumption seems to-day strongly in favor of its truth—furnish a remarkable and unexpected argument in support of the nebular hypothesis. The minds of many have been wavering of late with regard to this hypothesis; their doubts have been strengthened by the unqualified assertions that all nebulas are resolvable; but this analogy of

Kirkwood tends most strikingly to confirm it—so much, indeed, that if this latter be true, I do not know how any one can resist the argument which it furnishes in favor of the former, in so far as it applies to our solar system. It is then no longer a hypothesis, but becomes a probable theory.

I will give a very short sketch of the quantities I have used in repeating Mr. Walker's computation.

[Dr. Gould then gave upon the blackboard the masses of the planets, and the periods of rotation which he had used, differing from those used by Mr. Walker.]

These are the masses which I have used; and these are the times of rotation as given in the books. I do not know how accurate the latter may be considered; perhaps to minutes, perhaps even less so. I believe they have all been determined by the observation of spots. If so, what proof have we that the spots do not move, no matter what the number of rotations used in determining the period? I have marked the period of Uranus as doubtful, because I do not know upon what authority it rests, having only found it in a table of a popular work by Sir J. Herschel, with a mark of doubt prefixed. It does not agree at all with this theory.

In considering a question of this kind, we must remember the nature of our investigations. The subject is to a certain extent, necessarily general, and the appearance of precise harmony could not be expected even were our data exact, which they are not. The nature of the problem requires a general, not a special agreement between observation and theory. When we are considering the evolution of order from chaos, we cannot pretend to a knowledge of all the physical forces which exerted an influence. We go back to a supposed time when the planetary spaces were filled with nebular matter; we assume the existence of certain nuclei or centres of attraction; and, from our knowledge of the solar system, as it now is, infer the relative force which these several centres of attraction must have exerted, and assign to each its proportionate realm. If now we find that the spheres of influence belonging to the several nuclei are harmoniously connected, by a simple formula, with the periods of rotation as observed to-day,—an element before omitted in our investigations—we discover a remarkable corroboration of the probability of our hypothesis. This is what Kirkwood's formula professes to be—a simple relation between the time of rotation and the diameter of the sphere of attraction.

The subject being then a strictly general one, we are not warranted in demanding that exactness of numerical agreement, requisite for the verification of theories of a more special nature. If, as circumstances appear to indicate, more careful investigation should lead to the general adoption of the theory of Kirkwood, I should not desire that this should be denominated a LAW. Nature's laws must be precise and complete. The relation which we are considering claims only to be approximate—an analogy. And in speaking of it, I shall call it by this name, *Kirkwood's Analogy.* And where we have by hypothesis a right to expect analogy and not perfect accordance, the want of perfect accordance must not be considered to cast doubt upon the theory. Besides, if Kirkwood's Analogy were the result of a general law, would not the action of the law be modified in all probability by circumstances which would prevent us from perceiving any strict mathematical precision? The considerations which would be strong arguments against hypotheses of other kinds, do not appear to me weighty when applied to any thing so rude as the motion of chaotic matter.

There is a formula known as "Bode's law"—an empirical formula—expressing a supposed analogy, for which no reason was ever assigned and which, even before it was broken by the new planet Neptune, was found utterly devoid of that universality and precision which must characterize all laws of nature. Though it was considered a remarkable coincidence, and perhaps as capable of suggesting some law of nature, no true mathematician could ever have regarded it as a real LAW. Moreover, Gauss had shown long since that it did not hold for Mercury.

This "Law of Bode" was analogous to the theory of Kepler, that as there were but five regular solids, there could be but five planetary intervals, and therefore no planet between Jupiter and Mars.

Kepler's theory was totally overthrown by the discovery of Uranus, as the other has been by the discovery of Neptune. Bode's law, to which, by the way, Bode's name has been improperly given, would make the distance of Neptune beyond the orbit of Uranus nineteen times the distance of the Earth from the Sun, while it is in fact less than eleven times this distance beyond it, so that the fallacy of this formula must now be so evident as to require no demonstration.

Discordances such as those which exist in the application of this law to the planetary system, would afford sufficient reason for rejecting the analogy of Kirkwood; but, with even these discordances, the fact, that a single formula would approximately represent the truth to so great an extent, would justify us in bestowing much time upon its consideration.

[Dr. Gould then gave a brief sketch of the points of connection between the nebular hypothesis and the new analogy,—showing how the one would lead to the other.]

It will be remarked that in the phrase "sphere of attraction," the word sphere is not used in its geometrical sense. Nor is a planet necessarily in the centre of its sphere of attraction, for upon the one side, as is the case with the earth, may be a planet comparatively near, and upon the other a smaller planet at a greater distance; whence it is evident that the extent of the sphere of attraction will be much less upon the former side than upon the latter.

In Mr. Walker's theory he assumes x, in the equation $\theta=\frac{2\pi}{x}\cdot a^{\frac{3}{2}}$, to be a constant and equal to $\frac{1}{(k)^{\frac{3}{2}}}\cdot\frac{1}{365,256374}$, the term k being nearly 2. In the following formulas I shall denote the quantities which refer to the Earth by a single accent, those referring to Mars by two, to Jupiter by four, and to Saturn by five, reserving three accents for the hypothetical planet between Mars and Jupiter. I make use of Mr. Walker's formula for the sphere of attraction as follows:—D being the diameter of the sphere, a being the mean distance of the planet, and m being its mass.

For Jupiter we have

$$D^{iv}=\sqrt{m^{iv}}\left(\frac{a^{iv}-a'''}{\sqrt{m^{iv}}+\sqrt{m'''}}+\frac{a^{v}-a^{iv}}{\sqrt{m^{iv}}+\sqrt{m^{v}}}\right)$$

So for Mars;

$$D''=\sqrt{m''}\left(\frac{a''-a'}{\sqrt{m''}-\sqrt{m'}}+\frac{a'''-a''}{\sqrt{m''}+\sqrt{m'''}}\right)$$

In these formulas you will perceive that every thing is known, except the mass and distance of the new planet; or the *old* planet, if you please. The only assumption is the truth of the nebular hypothesis. If we knew the values of D^{iv} and D'', the spheres of attraction of Jupiter and Mars, we should have two equations and but two unknown quantities, a''' and m''', and should thus have this planet restored by the nebular hypothesis alone.

I have assumed in the computation for the value of k, not 2,—the constant which Mr. Walker supposes it to be, not only from his calculations, but from *a priori* reasoning,—but the mean of the values obtained from each planet, using the masses as given in the books, though affected of course, with some inaccuracy.

Now recurring to the above phenomena, let us take, for the sake of convenience,

$$D^{iv}-\left(\frac{a^{v}-a^{iv}}{\sqrt{m^{iv}}+\sqrt{m^{v}}}\right)\sqrt{m^{iv}}=A,$$

$$D''-\left(\frac{a''-a'}{\sqrt{m''}+\sqrt{m'}}\right)\sqrt{m''}=B,$$

and then we have,

$$\frac{m'''}{m^{iv}}A=a^{iv}-a'''-A,$$

and hence $\sqrt{m'''}=\dfrac{a^{iv}-a''-(A+B)}{\dfrac{A}{\sqrt{m^{iv}}}+\dfrac{B}{\sqrt{m''}}}$

Here all the quantities on one side are known, and we use the mass of the new planet thus obtained for the solution of the problem. This being substituted in either of the previous equations, will give us the mean distance of the planet.

Or, if for convenience we make $\frac{A}{B}\sqrt{\frac{m'''}{m^{\text{iv}}}}=C$

we shall have— $$a''=\frac{a^{\text{iv}}-A+(a''+B)\,C}{1+C}$$

Now the only question is as to the value to be adopted for Mr. Walker's constant, which it seems to me should be deduced from observation only.

In computing the value of k, I obtain for

Venus, ...	1.9374
Earth, ...	1.9030
Saturn, ...	1.9763
The mean of this, ...	1.939

is the quantity assumed for k, in obtaining the results of which I shall speak; these three planets being the only ones to which the formula can be applied. It will be seen that the values obtained are most confirmatory of Mr. Walker's results. Unless we suppose the nebular matter to have been equally distributed through the solar system, we could not expect to find k absolutely *constant*, even if it were an approximation to the number 2.

Prof. Walker here remarked that the constant used by Dr. Gould answered better than the constant 2.

Dr. Gould continued,—We do not know the extent of Mercury's influence inside its orbit, and hence cannot know the diameter of its sphere of attraction. Nor can we apply the formula to Mars or to Jupiter, for we do not know what planet may have been between them. We cannot apply it to Uranus, for we do not know its period of rotation. There remain but the three planets mentioned above.

Calculating, from the equations thus developed, the mass and distance which would belong to a planet between Mars and Jupiter, and thence, by Kirkwood's analogy, the corresponding time of rotation, we do not find it so great, that, by mere centrifugal force, the planet could have been exploded, and its mass scattered in the form of asteroids.

From a very rough computation of the place and size of the hypothetical planet, I obtain a mean distance 3.12,—and a mass $\frac{1}{801,300}$. This mass is very much smaller than the mass of our earth, and would agree with the supposition of a small planet, smaller even than Venus, but would be at least equal in size to twelve or fifteen Asteroids.

This gives rise to a great many speculations, most interesting and important in their bearing upon the theory of the universe. I wish to dwell upon the fact that we neither know accurately the period of rotation, or the mass of most of the planets. The only element which is really well known, is the distance of the primary planets from the sun. Then there is the difficulty to which I also alluded, in ascertaining the magnitude of spheres of attraction, that we cannot assume the nebulous matter to be equally dense; so that it cannot be demanded that the analogy should be very accurately expressed by any given data.

It is now extremely important that observations should be made upon the periods of the rotation of several planetary bodies, and it is much to be desired, as bearing upon this problem, that those who occupy themselves with what may be called the natural history of astronomy should determine the times of rotation anew, and thus enable us to decide upon the truth of a law, the discovery of which may be important in the history of astronomy.

Prof. Walker made a remark on Saturday, with reference to the position to which Mr. Kirkwood will be entitled, should his theory be found true. The Section seemed surprised at this remark. I do not wish to express myself strongly, but certainly when we look back upon the labors of Kepler, who strove so many years with results so unpromising, until he discovered the laws which underlie the whole fabric of our solar system, and then turn to Mr. Kirkwood, a teacher in the interior of Pennsylvania—who without the sympathies of kindred minds, or the use of any library of magnitude—without calling even upon the aid of strict mathematical analysis—has fixed his attention upon this one problem, and investigated it in all its bearings, until after ten years of patient thought and labor, he has arrived at such a result as this—we cannot but be struck with the similarity of the two cases; nor can we consider it as very derogatory to the former to speak hereafter of Kepler and Kirkwood together as the discoverers of great planetary harmonies.

ART. V.—*On the Natural Terraces and Ridges of the country bordering Lake Erie;* by CHARLES WHITTLESEY, of Cleveland, Ohio.

THROUGH the assistance of the engineers, engaged at various times, in surveys for railroads and canals in Northern Ohio, I have been enabled to determine the elevation of our "Lake ridges" at numerous points, between the Pennsylvania line and Sandusky Bay, a distance of 130 miles. I am more particularly indebted for these levels to J. H. Sergeant, Esq., who has run several lines west of Cleveland, and to Messrs. Harback and Smith, engineers for the Cleveland, Painesville and Ashtabula Railroad Company.

When these surveys do not cross the ridges and terraces, they have still been the basis upon which by short cross levels taken with a pocket instrument, I have obtained the elevations; and the results I think, cannot be wide of the truth.

There may be an extreme discrepancy of three feet among them, however, arising from changes in the surface of the Lake, which is the common plane of reference.

My opinion has been for many years, that the "*ridges*" are not "ancient beaches" of the Lake, although some of the *terraces* may be. It is indispensable to a beach, that it should at its foot or water line be *perfectly horizontal.* The Lake ridges are not so; and this fact, taken with the external form which they assume, clearly gives them the character of *submarine* deposits.

There are points on this coast where there are four ridges rising in succession from the Lake, as in the township of Ridgeville, Lorain County. In other places there are *three*, as from Geneva to Ashtabula; from Euclid through Painesville to Geneva, two; and from Cleveland to Euclid, one. There are places where it is difficult to trace any; and in others as at the city of Cleveland, where there are two or three branches or divisions of one ridge for short distances, all about the same level and liable to terminate suddenly. The ridges are sometimes upon the crest of a terrace, and sometimes lie, like a highway of water-washed sand, on the gently inclined surface of a plain, that descends towards the Lake. From a regular and beautiful elevated roadway, the ridge occasionally breaks into sand knolls, as at Avon Centre, Lorain County; at Ohio City near Cleveland, and at Painesville, Lake County.

Where nothing to the contrary is stated, the height given is that of the summit of the ridge, terrace or knoll. The first ridge, or that nearest the Lake, is known in the county as the "North Ridge." The others have different names at different places; as the "Middle Ridge," "Chesnut Ridge," "Butternut Ridge," and "South Ridge."

Elevation of the North Ridge, beginning at the Eastern part of the Western Reserve.

Conneaut, Ashtabula Co., above Lake Erie, . .	120 feet.
One mile west, ...	145 "
Four miles east of Ashtabula village, . . .	132 "
(Base of same for several miles, 85 to 95.)	
County line between Lake and Ashtabula Co., northern slope of North Ridge, .	107 "
Eight miles west in Lake County, . . .	125 "
Centreville, 1 mile north of village, . . .	105 "
Painesville, ...	120 "
Mentor—well defined for 2 miles level, . . .	109 "

Willoughby,	85	feet.
Seven miles east of Cleveland,	112 to 118	"
Three " " " "	113 " 118	"
Two " " " " at crossing of Cleveland and Pittsburg Railroad,	128	"
Cleveland city,	96 to 108	"
Ohio City,	114	"
Rockport, Rocky River,	90	"
One mile west,	105, 107 and 126	"
Avon, Lorain Co., east of Centre one mile,	85	"
" " " Centre sand knolls,	105	"
Russelton, Lyme, Huron Co.,	120	"

This table embraces a distance of one hundred and twenty (120) miles, where it appears the lowest summit is 85 feet, and the highest 145, showing a difference in longitudinal direction of 60 feet. I have not visited all the positions here given, but the greater part of them, and for the rest am informed by the engineers that there is no higher ground between the ridge and the Lake. In all cases there is a smooth uninterrupted plain, on the Lake side, over which the water of the Lake is everywhere visible, when the forest timber, which is heavy, is cleared away. It is variously composed of blue marly clay, of coarse drift called "blue" and "yellow hardpan," and of coarse sandy and gravelly drift; but the soil is for the most part clayey, and wet between and below the ridges. The streams, little and great, cut deep and steep gullies through the superficial deposits, and also into the rocks below. From the cliff limestone at Sandusky, eastward and to the state line, the superficial matter rests on slates, sandstones and shales, corresponding to the Hamilton, Chemung and Portage groups, of the New York Reports.

Elevation of the second Ridge, called the "South" and "Middle" Ridge.

Near Kingsville, Ashtabula County,	(south	ridge,)	152	feet.
Centreville,	"	"	122	"
Two miles east of Cleveland,	"	"	135	"
Two miles southwest of Ohio City,	middle	"	149	"
Dover Centre, 12 miles W. of Cleveland,	"	"	163	"
Rockport, 7 miles " "	"	"	130	"
Ridgeville, Lorain County,	"	"	168	"

This ridge is more broken and less continuous than the first, or "north ridge," and is in general heavier. In Rockport, Dover and Ridgeville, on the northern or Lake slope, it is from 16 to 20 feet above the base at its foot, and on the rear 5 to 10 feet. Behind it, as with all the ridges, is flat, swampy land, and small rivulets that drain the low ground, running parallel with the swell, to some creek, or occasionally breaking through towards the Lake. These lands are very rich, and with a moderate expense are drained by ditches cut through the ridge. The slope of the flat lands between and before the ridges is sufficient to carry off all the water in ditches that have a free current. Most of this land is coming under the plough in this manner, although it is equally well calculated for grass. No country can possess more rural beauty than that along these "ridge roads." The land in a longitudinal view, is apparently level, as far as the eye can reach; and the buildings congregated along the line of the road appear to be arrayed in curved lines, gently waving to the right and left as you proceed. Looking from one of the interior ridges, which are generally perceptibly higher than the next one towards the Lake, if the timber is not standing, another, and rudely parallel row of farm houses, barns, orchards, &c., is seen at the distance of one, two or three miles; the intermediate space perfectly smooth and cultivated, and beyond lies the blue water, and the horizon.

The composition of one ridge does not materially differ from another. It is formed of coarse, water-washed, yellowish sand, or of fine gravel, principally the comminuted portions of the adjacent rocks. The rocky fragments are not generally worn perfectly round, or oblong, as beach shingle is, but are more flat, with worn edges. There are mingled with the sandstones and shales that compose this gravel, scattered pieces of quartz, flint, also granite, and trappean rocks, limestone and ironstone.

The basis of the ridge corresponding with the impervious clayey soil between, gives rise to a great many springs on the Lake or lower side; and this water frequently deposits bog iron ore, that has been used extensively in furnaces along the lake shore.

From near Dover Centre, west to Elyria, and even to Vermillion River, the second or "middle ridge," rests on a coarse grained sandstone or "grindstone grit," which farther east in Cuyahoga County rises above the level of the Lake ridges. Between the Black and Vermillion rivers, I have not succeeded in procuring the elevations. Here they are well developed, and show more branches or collateral lines, extending from one ridge to another, than is observed farther east.

By digging shallow wells, the inhabitants find water in abundance, and generally good. In these wells from 12 to 18 feet deep, there are thrown out as a common occurrence, sticks, timber and leaves, in a decaying state. I have in my cabinet some pieces of this wood, furnished by Dr. Moore of Dover, who took it from a bed of carbonaceous matter in a well of his, twelve feet below the surface. The well is situated on the middle ridge, 163 feet above the Lake. Pieces of timber six inches through have been found, represented as being water-worn like drift-wood. Those in my possession are solid, with a very fine grain resembling the willow.

Dr. Moore, an intelligent physician of my acquaintance, says he has seen shells thrown from the bottom of wells, resembling "periwinkles," a common name for Lymnea. Similar shells in fragments are said to have been thrown from a pit two miles west of Cleveland, on the north ridge. In the "blue marly clay" beneath this ridge, I have found a Helicina, and a Planorbis, shells characteristic of the loess of the Rhine, and of St. Louis, and the Wabash in Indiana. The palæontological evidence is therefore, as far as it goes, in favor of the idea of very recent and fresh water deposits.

It will be seen from the second table of heights, that the greatest difference is there forty-six feet; and that the summit of the ridge rises, from Rockport to Dover in seven miles, thirty-three feet, but from Dover to Ridgeville, six miles, it is nearly level.

Through these two distances, making thirteen miles, the height of the ridge above its base is about the same, from sixteen to twenty feet; and consequently the base has an equal rise in a longitudinal direction. Two miles west of Ridgeville Centre, the top of the middle ridge has descended from 168 to 149 feet. The foot of the north, or first ridge, and of the terrace on which it is frequently situated, approaches nearer to a horizontal line than the ridge itself, but still differs from a perfect level. It is at

Conneaut Creek,	75	feet.
Four miles east of Ashtabula,	85	"
Several miles west of "	95	"
Painesville,	85	"
East of Willoughby, several miles,	60 to 65	"
Three miles west of Willoughby,	60	"
Euclid Creek, 12 miles east of Cleveland,	75 to 85	"
Seven miles east of "	105	"
Two " " "	102	"
Ohio City,	75	"
Rockport,	70	"
Avon,	70	"

It is not easy to determine with precision where the base or foot of a ridge graduates into the plain; and consequently there is not that accuracy in the elevations for the base, just given, that we attain when measuring the summit or crest. But they are a close approximation, and although remarkably uniform, are by no means equal, as they should be if the base of the ridge represented an ancient coast-line; the greatest difference being forty-five feet, or about the same as the variation along the top of the second ridge.

There are but few measurements in my reach of the third and fourth ridges. In Huron County, south of *Russelton*, there are two low swells of land parallel with the shore, apparently about on a level with each other, and not much above the main ridge at Russelton, which is reported at 120 feet.

The third ridge, in Ridgeville, Cuyahoga County, is one mile southerly from the second or "middle ridge," and is not very prominent, rising six to ten feet above the low ground. At this place it is 186 feet above the lake, or eighteen feet above the middle ridge, and eighty-one above the highest part of the north ridge in Avon, five miles north.

The fourth or last and highest well defined Ridge.

2½ miles southwest of Ohio City, . . .	173 feet.
1¼ miles southeast of Ridgeville Centre, . .	203 "
West bank of west fork of Black River, Elyria,	195 "

Distance embraced, twenty-five miles.

The materials of the most southerly or interior ridge, are in general coarser than in the others, showing a more violent or less lasting aqueous action. This is observed everywhere at the west. The more *elevated the drift*, the more does it exhibit the effects of *strong currents* in the transportation of large pieces of rock, in the shape of coarse gravel. The lower portions, especially those that lie near the surface of the great Lakes, not only on Lake Erie, but on Michigan and Superior, are fine, argillaceous or marly, laminated, and with few pebbles.

The terraces have not been as much noticed as the ridges, and consequently their height is not as well known. From Rockport to Avon, the north ridge is upon the edge of a terrace, the foot from seventy feet above the lake, down to sixty feet; its crest from one hundred and five down to eighty-five. Directly opposite this, about five miles more inland, a considerable portion of the fourth or south ridge, (known as the "Butternut,") is also on a terrace of about twenty feet, on its northern face; in fact all the ridges partake of the nature of terraces, in places; the northern slope being generally the longest. But the geological composition of the terrace on which the ridge rests is different, and either a rock or a drift of more compact and resisting kind.

Between Newburg and Euclid, nine miles, the northern face of the terrace is very bold, its base from 120 to 150 feet, and its crest 200 to 225 feet. It is here composed of fine grained sandstone (Waverly), and blue and red shales. East of Euclid, the terrace sometimes divides into two, the lower one supporting the north ridge. It is the same for several miles east of Willoughby, the crest of the first or lowest terrace being about one hundred feet and its base seventy to eighty feet, and formed of blue hardpan resting on shales. In Erie County, on the line of the Mansfield railroad, it is composed of cliff limestone supporting black slate; its base about 130, and its summit 180 feet.

It will be interesting now to compare the elevations above given, for ridges in Western Ohio, with those of the great lakes in other states. In Michigan, at the east line of Washington county east of Ann Arbor, is a well-defined ridge running nearly north and south, whose summit is 140 feet above Detroit River, at Detroit. Around Monroe, in Wayne county, Michigan, are some irregular sand ridges, not more than thirty feet. They are also visible on the north shore of Lake Erie, in the flat country between Erie and Huron; their elevation is not known, but they are apparently as high as 200 feet.

Mr. Roy, a Canadian engineer, has made a section across the ridges back of Toronto to Lake Simcoe, as reported by Mr. Lyell, and has given their respective elevations as follows:

No. 1.—one mile north of Toronto, 20 to 30 feet high—base above Lake Ontario, ...	108 feet.
No. 2.—2½ miles from Toronto, 50 to 70 feet high—base above Lake Ontario, ...	208 "
No. 3.—5 miles from lake—10 feet high—summit,	288 "

Five other ridges *or terraces* are given by Mr. Hall, in the geology of the 4th district of New York; also on the authority of Mr. Roy, referring apparently to the elevation of their base.

No. 4.—above Lake Ontario, ...	308 feet.
No. 5. " " "	344 "
No. 6. " " "	420 "
No. 7. " " "	680 "
No. 8. " " "	762 "

Mr. Lyell observed *eleven* ridges between the Lake and the summit for Lake Simcoe, the elevation of the eleventh, or last and highest, corresponding with No. 7, of the New York Report. The elevation of Lake Erie above Ontario is generally stated at 332 feet, so that the three first ridges or terraces, in rear of Toronto, are below the surface of Lake Erie.

Mr. Barrett, a New York engineer, furnished Mr. Hall with the height of some points on the Lockport ridge, south of Lake Ontario and opposite Toronto. They are as follows:

At Lockport, ...	158 feet.
Middleport, 10 miles east, ...	185 "
Albion, Orleans county, ...	188 "
Brockport, Monroe county, ...	188 "

None of these correspond in height with those on the north shore, as they should do if they were the result of littoral action at a beach, for the surface of the water would be level. If we suppose them to have been formed in that manner, when the water stood at the base of a ridge, the rivers must have discharged at the same level. Here should, on that hypothesis, be found deltas, and evidence of bays or lagoons. The waters having settled away, at the present period the streams discharge at a lower level, their channels being worn deeper and larger, cutting through the ridges and terraces that lie between the present and the ancient level. If the ancient mouth was at a point different from that where the present channel cuts a ridge, it should be visible in the present form of the ridge. If it was at the same point, there should be marks of such action as always accompanies the meeting of running currents with dead water. But our streams appear to cut the ridges as though they were barriers preëxisting, and broken through by the current.

Terraces composed of the rocks or other general deposits of a country, appear to be much stronger proof of ancient shores than limited sand ridges. When we rise above 240 feet from Lake Erie, the well defined terraces disappear; and from that line to 600 to 650 feet, the general elevation of the table land in North-eastern Ohio, the surface presents a confused arrangement of heavy drift, covering the rocks at various depths, in long massive knolls, without ranges or parallelism. Towards the west, the summits of the lake streams are lower, and the present surface of North-western Ohio and Northern Indiana, of Illinois, Michigan, New York and Canada West, with much of Wisconsin and Iowa, would be submerged by a sea rising 250 feet above Lake Erie, or 815 above the ocean.

The Wabash and Maumee summit, at Fort Wayne, Indiana, is 246 feet above Lake Erie. The summit between the waters of

Saginaw Bay, and of Lake Michigan, .	108	ft. above	L. Erie.
Summit between Pishtaka and Rock River in Illinois, ...	218	"	"
Lake Winnebago, ...	177	"	"
Summit between Lake Ontario and Lake Simcoe, Canada, ...	197	"	"
Mouth of St. Peter's River, Fort Snelling, Minesota, ...	179	"	"
Missouri River at Fort Leavenworth, west line of state of Missouri, ...	181	"	"

If, therefore, the relative level of the land was the same as now, when the diluvial sea existed at high levels, its extent must have been very great, at the supposed stage of 250 feet above Lake Erie. At this or any other supposable stage, if it remained stationary long enough to form cliffs and banks at one place, it would produce the same effects, in kind if not in degree, at another; and we should be able to trace beaches or shores over all the vast west, for such cliffs are due to the action of winds and waves, always in operation on bodies of water. But under-surface currents are not universal, or in such general operation as to form everywhere, bars and longitudinal banks or spits. If the Atlantic Ocean should suddenly settle one hundred feet, or any other distance, would there not remain a distinct shore, well defined and traceable its entire length? At the mouth of some rivers and bays or inlets, would be seen limited sand ridges, their bases upon an exact level. On the ancient bed of the sea opposite sandy coasts, like North Carolina and New Jersey, would appear long, narrow and rudely parallel ridges, of such materials as are easily moved by currents, that would *not* be level longitudinally.

The evidence of the existence of ancient currents acting upon the drift, regularly and irregularly, is abundant. They have acted at all elevations, as well on the highest lands in Ohio at 1350 feet above the tide, as at the sources of the Mississippi, 1680 feet. The evidence is that they were powerful, and in general erratic or irregular and fitful. Such currents would not leave ridges, but rounded elevations. For this discussion it is immaterial whether the relative change in the level of land and water was due to subsidence or upheaval. The change has taken place, and before that period there were at great depths currents of water, both gentle and strong, giving form to the present exposed surface of the earth.

It is to this wide-spread power that we must resort, to explain most of the diluvial phenomena which are observed. What can be reasonably assigned to the wearing action of waves along a coast line, is limited and not pervading; not an universal, but a local, tardy and inefficient geological agent.

Art. VI.—*On the Quantity of Heat evolved from Atmospheric Air by Mechanical Compression*; by John Garric, M.D.

Physical science teaches us that condensation of matter is, with a few apparent exceptions, an invariable source of heat. Atmospheric air, subjected to mechanical compression, evolves it in large quantities, and in proportion to the degree of force applied. But though this general fact is well known, and has been examined by numerous and able experimenters, the numerical quantities of heat furnished by given volumes, under given pressures, have never been accurately ascertained. It may, indeed, be said that there is scarcely a subject in the whole range of natural philosophy, which has elicited more discordant results.

Every phenomenon of nature possesses in itself an interest well calculated to excite the mind to an investigation of its cause.

In acquiring a right understanding of the part it plays in the general system and economy of nature there is a gratification independent of all pecuniary or selfish considerations. But in the solution of the question, "what is the quantity of heat given out by the condensation of air?" there is a more immediate interest arising from the practical use to which the fact may be applied. It is favorable to the interests of science that the prospective value of the knowledge has justified experiments on this subject, as objects of commercial speculation; for otherwise its full elucidation would require an outlay of money too heavy to be expended by the mere lover of nature.

The atmosphere, from any thing we can observe taking place in it, affords but a remote and insignificant idea of the extensive relation existing between it and heat. Our sensations may indicate suffering from diminution, or inconvenience from exaltation of temperature, and the thermometer may mark the extent of its changes; but neither furnishes us with any evidence of the absolute or even the comparative quantity of caloric in air. Other considerations, however, present us with reasons for believing that it contains more of the principle of heat, in proportion to its absolute quantity of matter, than any other body found in a natural state.* Though not experimentally demonstrable, it cannot be doubted that the aerial form of the atmosphere, like that of vapors, is caused by the presence of a definite amount of heat.

Air may be condensed and dilated any number of times, and there will be with each change, a simultaneous and proportional diffusion and absorption of heat. The determination of the quantities of caloric thus alternately set free and rendered latent, is, apparently, a simple problem, which it is generally thought can be easily solved. But to furnish precise results not only is science and experimental skill demanded, but quantities of air must be used which imply a magnitude of apparatus, with facilities for manipulation, such as private philosophers can rarely command. It is true that if "instruments be exceedingly exact, and an experimenter be fully equal to the task of using them properly," the error upon moderate, may be quite as small in proportion as upon large quantities of most substances. But in this assumption, qualifications are implied to which few experimenters can lay claim; nor when possessed, would they be adequate to insure perfect accuracy in operating upon so attenuated a fluid as air which larger apparatus might attain.

In the attempts to determine the quantities of heat set free or absorbed by changes in the volume of air, these principles are well illustrated; they have been rendered very difficult and replete with errors, from the delicacy of manipulation employed, and the consequent minuteness of result to be ascertained. Limited by the convenience and necessity of economy, philosophers, in their experiments on this subject, have been in the practice of using very small quantities of air. Thus narrowed, the endeavors to ascertain the quantity of heat evolved by the condensation of such a fluid, surrounded as it must be, by a comparatively great weight of matter, and extent of conducting surface, have produced an apparent effect so insignificant, or the means of measuring it have been so imperfect that it cannot be said truth has been approached.

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* According to what are considered the most accurate experiments and deductions on this subject, the absolute heat of atmospheric air, estimating it from the standard of the absolute heat of water, viz. 1,000—is 18,000. See Mudie on the air, page 115.

In an investigation for the improvement of science, and still more when it is proposed, as in the present instance, to apply it to practical purposes, it is highly important to fix and determine essential data. So indispensable are they to any useful result, that too much care and nicety cannot be spent on them; because when once done with the accuracy of truth, they not only lay a foundation, upon which we may without rashness hazard fame and fortune, but they save much labor by forming a constant for any number of calculations, or any modification of experiments. In regard to air, the change in its sensible temperature, under an increase of density, is known to be great from the fact that by its sudden compression we may inflame tinder, and many other substances immersed in it. This trivial experiment, although in itself too indeterminate to found a valuable conclusion upon, has formed the basis of many chemical researches, having for their object the solution of the question in view.

To aid in determining the precise temperature to which compression would elevate gases, M. Thenard, many years ago, made a number of ingenious experiments. In trials with gases other than air, chlorine and oxygen, he used fulminating powders which exploded at different temperatures; and thus found that substances which decompose at 205° Centigrade, or 401° Fahrenheit, exploded in hydrogen, azote and carbonic acid, when compressed suddenly and strongly by hand in a glass tube. These experiments indicate that a very considerable accession of temperature may be obtained from the condensation of gases which are not supporters of combustion; but, admitting that atmospheric air conforms to the same law, the force employed is too vaguely expressed to show a precise relation between the heat evolved, and the compressing power. They are, however, interesting as proving that considerable intensity of heat may be obtained by trivial means, under unfavorable circumstances.

About the same time that M. Thenard made his experiments, M. Colladon instituted others better calculated to determine an exact limitation of the heat set free from air by compression. He states that to ignite sulphur, it is necessary to reduce atmospheric air to one-eighteenth of its volume, and to set fire to starch, to one-thirtieth.*

Philosophers, in their experiments on air, have been in the practice of dividing it into certain proportions—as the half, the fourth, the eighth of the volume experimented upon—and of considering each division as affording an equal measure of heat as the result of condensation. Now, the number of such divisions in reducing air to one-eighteenth of its volume, is a little more than four, and to one-thirtieth, nearly five; while the temperatures at which the above named substances burn, may be stated respectively, at nearly 500° F. and 600° F. Here we have data, which if correct, would at once solve the question involved. By dividing these numbers by each other we shall have as the result of the compression of air, about 120° F. for every reduction of it to half its previous volume. If these data could be relied upon, the subject would need no further investigation; but so different have been the conclusions from analogous experiments in the hands of the other philosophers, that new and more satisfactory ones are demanded. For while, as we have seen, M. Colladon says it requires a condensation of atmospheric air equal to one-thirtieth of its volume to ignite tinder, M. Gay Lussac, who made similar experiments on a larger scale, estimates that a reduction to one-fifth is sufficient.†

Nor have other experiments and processes of reasoning, for deducing a precise solution of this apparently simple question, though conducted by the most eminent chemists and mathematicians of the past and present ages, been more uniform or more satisfactory. The methods of proceeding have been different from each other, and from those already referred to, but they show a similar variance, of from one to five and upwards, in their deductions.

Dalton found, in experimenting with the common air-pump of the laboratory, that if the density of air be suddenly doubled by compression, its temperature rises 50° F. This experiment is among the earliest we find on the subject, and comes, if we can regard the 50° F. as computed at the standard of the specific heat of water, nearer the truth, for the first reduction of air from its ordinary temperature and pressure, to half its volume, than any subsequently recorded.

According to some experiments of Leslie, conducted upon a somewhat different plan, it would appear that atmospheric air rarefied until its density was three-fifths of its natural density, when suddenly restored acquired about 48° F. of temperature.

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* American Journal of Science [I], vol. xx, p. 180.

† It will be shown in the course of this communication, how this very great difference in apparent result, may arise from comparatively small errors of the experiments.

Professor Espy states as the result of experiment, that if air have its density doubled or be reduced to half its volume, its temperature will be increased about 90° F., and that air expanded to half its density, or double its volume, generates a cold of about 90° F.

That accurate and profound mathematician, the late Mr. Ivary, has attempted to deduce from calculation, upon data to which I have been unable to get access, the precise quantity of caloric given out by the condensation of atmospheric air. According to his estimate one degree of heat is evolved from it, when under a condensation equal to $\frac{1}{180}$ of its volume; and consequently, if a volume of air be reduced to half its bulk the heat given out will be equal to 180° F. Both Laplace and Leslie, in attempts to reconcile the calculated velocity of sound, with that which is deduced from experiment, made similar calculations; but the theorems by which they are expressed are both abstruse and inaccurate, for though they regard the quantity of heat evolved from air by condensation as "profuse and powerful," the amount the latter assigns is less than that mentioned by Mr. Ivary; and his estimate, it will be seen, does not equal the truth.

The researches of M. Gay Lussac, to whom science is more indebted for an extensive and profound investigation of this subject than to any other philosopher, led him to consider a condensation of air into one-fifth of its volume as sufficient to ignite tinder—a degree of heat which he states is almost 580° F. This estimate, applied to volume, according to what has been mentioned as the custom of experimenters, would give about 280° F. for every time the density of air was doubled.

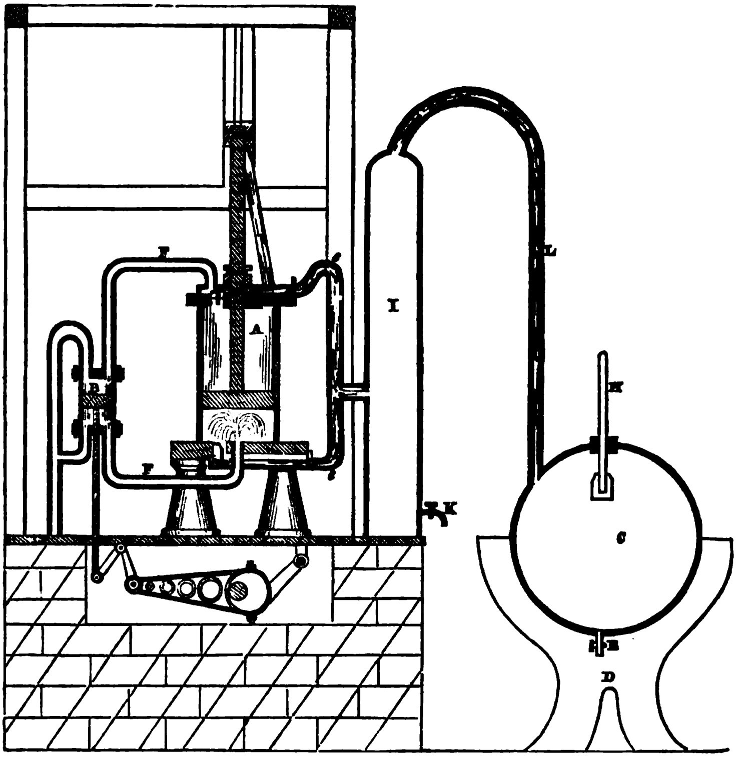
Upon a subject on which so many scientific men have directed their attention and tasked their ingenuity to discover methods of accurate observation, it would seem presumptuous to attempt to devise processes more exact than have been already employed. Yet the diversity in the results furnished by such able experimenters renders questionable the truth of any of them, and shows that their modes were defective, or, at least, that fresh investigation is necessary to enable us to confirm or reject their data with certainty. That in the general economy of nature the relation of caloric to air is of high importance, and that the investigation of the laws of their action is worth the labor they may require, and is indeed one of the most interesting enquiries, in both a scientific and practical point of view, to which the attention of mankind can be turned, are apparent from considerations already alluded to.

To improve our knowledge of these relations, so as to deduce the laws by which they are governed, we must study the subject on a larger scale than it has been heretofore examined; and with an object in view sufficiently valuable to justify the expenditure of money for adequate machinery, and of time for a long series of careful and precise observations. Experiments on a small scale, upon a material so attenuated as air, can scarcely be expected to speak absolute truth, or to answer the question as to what is the actual result of large operations. And besides being on a scale of suitable magnitude, they cannot be made accurately by rude and unskillful hands; they must be performed by persons qualified by knowledge and practice to conduct them through all the circumstances which a great range of temperature, and a variety of degrees of condensation may present. By conjoining expectations of pecuniary profit with philosophical views, it has been placed in my power to fulfill these conditions, and by a long course of expensive experiments, amidst much embarrassment of many kinds, to elicit a near approach to truth. A portion of the money expended in conducting these experiments, was furnished by some commercial gentlemen of the city of New Orleans.

As the object of these gentlemen, in advancing their money, was pecuniary gain, and this depended upon the quantity of heat absorbed, or in other words, the quantity of cold produced, and its applicability to the manufacture of ice, from the expansion of air after its condensation, I was constrained to pay as much, perhaps more attention to the evolution of this effect than to the quantity of heat disengaged by the condensation. Two series of experiments were thus carried on at the same time, and each was made to act as a check upon the accuracy of the other; while no labor or care was spared to render both accurate. To make these experiments, a large and powerful machine has been constructed, planned for measuring alike the heat developed by condensation, and the heat absorbed by rarefaction of any volume of air—from two cubic feet to two thousand cubic yards or more, and under any degree of condensation from two to eight atmospheres. By operating with such masses of air, the errors into which previous experimenters had fallen, have been, in a great measure avoided.

In the present article I propose to give an account of the quantity of heat evolved by the condensation of air under a compressing force of from two up to eight atmospheres consecutively; and in a succeeding number of this Journal to show the quantity absorbed by the expansion of the same air from a tension of two, four, and eight atmospheres, to the ordinary atmospheric pressure.

The machine, already mentioned as constructed, was intended for measuring alike the heat evolved by the condensation of air, and the heat absorbed by its subsequent expansion. The portion employed for the former purpose is represented in the figure below, which is an end view of the whole machine, and consists essentially of a large double acting force pump, A; a smaller force pump, B; and a reservoir or air magazine, C.



The larger pump, A, is constructed on the common principles, well known to mechanics, of the double acting force pump for air or water; and its object is the condensation of atmospheric air. It receives the air through valves, which may be constructed like the induction valves of the low-pressure steam engine, but which, in the present instance, are placed in the lids, opposite to each other, and open inwards. After compressing the air to the required degree, this pump forces it through eduction valves into the pipes *e*, *e*, which lead to the reservoir. The pump is thirteen inches in diameter with a twenty-four inch stroke of piston; and consequently, has a capacity, exclusive of the space occupied by the piston rod, of 3144 cubic inches.

Besides this large pump there was a smaller condensing pump, (not seen in the figure,) four inches in diameter, seventeen inches stroke, and, after deducting the average space occupied by the piston rod, of 206 cubic inches capacity. This pump was fitted with valves, and communicated with the reservoir, in the same manner as the larger pump. Its object was to charge the reservoir with air to any required tension before setting the larger pump and its antagonistic engine in operation, and thus save the enormous consumption of power which, it was supposed, would be required to work the larger pump so as to obtain the same effect. Though theoretically necessary, it was found in practice that it could be advantageously dispensed with, and will not be introduced into any future construction of the machine. But as it was attached to it, and in most of the experiments to be hereafter detailed, its measure of air was condensed at every stroke of its own and the larger piston, its operation must be taken into account in estimating the heat evolved by the condensation of a given volume of air. Added to the capacity of the larger pump, (3144+206=) it made the whole quantity of air condensed by every stroke of the pumps or every half revolution of the engine, 3350 cubic inches.

The smaller pump, B, is also double acting, and of 56 cubic inches or one quart capacity. It is designed to inject that quantity of cold water through the pipes F, F, and a sieve-like plate, or "rose" placed in the upper lid, and several perforations in the lower lid of the larger pump, and thence distribute it, in a finely divided shower into the interior of that pump. Its object is to absorb the heat of elasticity set free from air by its condensation, and at the moment of its generation, so as to lessen materially the mechanical power that would otherwise be consumed. As it effects this object by mixing intimately the water and air, and causing the former to absorb the free heat, it renders the water an excellent approximate measurer of the heat evolved. After performing this office the water passes out of the pump, with the condensed air, into the reservoir.

The reservoir, or air magazine, C, employed in these experiments, is cylindrical in form, eleven feet in length, thirty-two inches in diameter, and has a capacity of about sixty-two cubic feet. It is made of sheet iron, with hemispherical heads, in the manner of a steam boiler. It is furnished with a safety valve about three inches in diameter, and loaded with a weight, through the intervention of a lever. At one end it has a man-hole affording admittance into its interior; and it is provided with a stopcock, E, inserted into its most dependant part, through which the water of injection, received from the pumps, and precipitated from the air by its greater specific gravity, may be discharged into the open atmosphere, or returned again to the pump, B, for a renewal of its duty. It is supported by three cast iron frames, one of which is represented at D.

When the air attains a certain pressure in this reservoir, it is allowed to discharge itself, by means of a communicating pipe, into an engine which works expansively through a valve so constructed, as to permit of being arranged to cut off the communication with the reservoir at any portion of a stroke. The air in this way, and independent of the safety valve, is prevented from attaining more than a certain degree of pressure.

There were several appendages to the machinery employed in these experiments which were not absolutely necessary, and would not be used in a practical application of the principle. Among them is the vessel, I. This was a reservoir of a former experiment, and was used, in this instance, to separate the water of injection from the condensed air, the former of which passed through the cock, K, while the latter proceeded through the pipe, L, into the reservoir, C. It is mentioned, and represented in the drawing, in order that all the circumstances attending the experiments may be understood.

As a means of measuring with precision the pressure of air in the reservoir, a gauge consisting of a glass tube, closed at the upper end, having a length of twelve inches, and an internal diameter of a quarter of an inch, was used. After filling this tube with dry air, and inserting it through the upper surface of the reservoir, into a cup of mercury, in communication with the air within the reservoir, it was found to act as a convenient manometer capable of giving the same indications, by the contraction of the contained air, as would have been given in similar circumstances by a column of mercury, placed as in the barometer, and of a height due to the density of the air. The accurate graduation of this instrument presented some difficulties, and was approximately attained by filling it with successive equal-weighed portions of mercury, and marking on the glass tube, and a metal scale surrounding it, the volume thus indicated. These marks were intended to express the scale of heights of the mercury, above its original level in a cup, in atmospheres of thirty inches in height. The instrument requires for perfect accuracy, corrections for changes of atmospheric temperature, as well as for the increased temperature of the air enclosed in the reservoir. But disregarding these sources of error, and probably some in charging the tube with mercury, it was found to be a valuable instrument; its indications were not only more easily attained, but were more accurate than those of the steam indicator, or common safety valve.

The standard which I have relied upon, in conducting the experiments of this research, for determining a measure of heat, is the assumed quantity required for the conversion of a pound of ice into water. In the absence of any experiments of my own upon the subject, I have taken the quantity at the generally received one of 140° F., though some observations incline me to consider it as several degrees less.

With the foregoing apparatus numerous experiments have been made; but as a small number, conducted on proper scientific principles—more particularly if they agree with each other, and have been, as in these instances, checked by the observations of two persons—are as satisfactory as any greater number, I have detailed, and given the calculations in full of only a few. These will serve as examples for any one who is disposed to compute from the observed data, the resulting quantity of heat obtained, and thus prove the truth, or error of the reported result. Finding that observations were made with more accuracy in proportion as experience familiarized me with them, I considered that the later ones were more to be trusted than the earlier, and I have, therefore, with one exception, selected them for this communication. The exception referred to, is contained in the first of the following tables,* and was the earliest experiment made by me with the machine I have just described. It is introduced for the reasons that it cannot be materially inaccurate, and that the temperature of the atmosphere at the time, was very different and much lower than at any of the later experiments.

It is proper to remark that in conducting these delicate experiments many causes of error have been either unavoidable, uncorrected, or overlooked. Owing to defects of mechanical contrivance and unskillful workmanship, incidental perhaps to every new device, and a noviciate intercourse with practical mechanics, the machine was not capable of performing all its duties with the accuracy the natural laws involved called for. And notwithstanding a great desire to avoid and correct errors from the leakage or irregular working of the machine, by compensating for them, I cannot in all cases rely upon the correctness of the allowances made therefor.

The thermometers used in these experiments were manufactured in New Orleans, and their indications differed so much from each other that they could not be fully relied upon. The nature of the investigation required instruments that should mark, if possible, the tenth part of a degree of Fahrenheit; but none that I could obtain was of sufficient sensibility to be read accurately within half a degree; and, therefore, all indications set down as more minute, must be regarded as conjectures, or interpolated calculations. As I found that no two thermometers agreed with each other, I was aware that it was desirable one or more should be verified by a comparison with the indications of an unquestionable standard, but this was not attainable. One common source of error, however, in the observations of the thermometers was avoided. Apprehensive from the smallness of their scales of graduation that difference of vision might lead to error, I was careful to obtain frequent observations from two or more persons, and in no instance, where there was a difference of opinion, was the observation recorded. Still, it is possible that the conclusions arrived at may in some instances be inaccurate; for I found that when observations were made by two persons on the same thermometer, they often differed from each other as much as a degree, and there is reason for supposing that even when alike they might be erroneous. I have dwelt upon the possibility of error from the imperfection of both thermometers and observers, because from the mode of experimenting adopted, a slight difference between the actual heat evolved and that observed, would present a very considerable difference in the proportion in the air itself.

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* See continuation, in next number of this Journal.

The want of a barometer prevented any modifications in the calculation of results, on account of variations in the density of the air.

(*To be continued.*)

Art. VII.—*On the Computation of the Sun's Daily Intensity at the exterior surface of the Earth, and Secular Changes of Heat;* by L. W. Meech, A.B., Preston, Ct.

There are reasons for believing that the phenomena of solar heat may be as completely interpreted by analysis as are the tides of the ocean. The subjoined contribution is offered in pursuance of this object.

I. Before proceeding to the general investigation, let it be proposed to determine the diminution of heat arising from the secular decrease of the eccentricity of the earth's orbit: in consequence of which, the orbit approaches to the form of a circle, and the earth is constantly removing to a greater distance from the sun, between the apses; the transverse axis remaining invariable. Let then e represent the eccentricity, regarded as constant for one year; ρ, the radius-vector; φ, the mean anomaly; and θ, the true anomaly, for any given time. Also it is known that $\pi\sqrt{1-e^2}$ expresses the whole area of the ellipse; and $\int\frac{1}{2}\rho^2 d\theta$, that of the elliptic sector corresponding to θ. Whence by Kepler's law of equal areas,

$$\pi\sqrt{1-e^2} : \int\tfrac{1}{2}\rho^2 d\theta :: 2\pi : \varphi, \text{ or}$$

$$\frac{1}{\rho^2} = \frac{d\theta}{d\varphi\sqrt{1-e^2}}.$$

Since heat varies "inversely as the square of the distance" ρ, this equation evidently measures its intensity. To obtain the sum of the intensities in a year, the equation must be multiplied through by the uniform $d\varphi$, and integrated between the limits o and 2π: then rejecting the constant factor 2π, there remains the relative

$$\text{Annual amount of heat} = \frac{1}{\sqrt{1-e^2}}. \qquad (1.)$$

Again, let the slight decrement of e in one or more centuries be denoted by h; writing $e-h$ in place of e and developing for the first power of h by Taylor's Theorem; there results the proportional

$$\text{Secular diminution} = \frac{-eh}{1-e^2} = -eh - e^3h - \ldots \qquad (2.)$$

On January 1, 1801, the value of e was 0·01678357, with a centurial decrement of −0·00004163, the centurial value of h. And at this rate the orbit would become a circle in 40,300 years, though it is improbable that it will reach this limit. The diminution in a century is readily ascertained by substituting the values of e, h, in the last formula, which gives − 0·000 000 69; and it will be shown hereafter in the computation for Mendon, that such numbers are nearly or quite proportional to the corresponding degrees of Fahrenheit's scale. Hence the secular decrease of the annual quantity of heat, arising from secular change of the sun's distance alone, is too small to be sensible to the thermometer in a hundred years, in a thousand, or in ten thousand years, and scarcely so, at the utmost limit, when the orbit becomes a circle. For even then, the mean temperature on the equator, which is now 82°, would not fall more than 0·025 of a degree of Fahrenheit.

It is thus demonstrated that the mean annual heat received by the earth as a whole, is virtually constant during a sidereal year, so far as secular change of the sun's distance alone is concerned; and by reason of the nearly constant excess, the same may be concluded of the tropical or civil year.

II. Again, let it be proposed to ascertain *the sun's relative intensity at any given instant during the day.* For this purpose,

Let L = the 'apparent' Latitude of the place,
D = the sun's meridian Declination,
Δ = the sun's semi-diameter,
A = the sun's Altitude, and
H = the Hour-angle from noon.

The horizontal projection of the sun's disc on a plane at the exterior surface of the earth is well known to be an ellipse; and if 1 denote the sun's radius, 1 will likewise denote the semi-conjugate axis of this projected ellipse; while the horizontal projection of 1, which is $\frac{1}{\sin A}$, will be the semi-transverse axis. The area of the elliptic projection is therefore $1 \times \frac{1}{\sin A} \times \pi$. But the intensity of the same quantity of heat being inversely as the space it covers; the reciprocal of this area $\frac{\sin A}{\pi}$, or rejecting the constant divisor π, *sin A will measure the sun's intensity at the altitude* A, supposing the distance to be constant.

But the sun's intensity further varies inversely as the square of the distance, that is, directly as the square of the apparent diameter or semi-diameter of the disc. Hence

$\varDelta^2 \sin A$ measures the sun's intensity at any given instant during the day.

To assign the value of sin A, by spherical trigonometry, the sun's distance from the pole or co-declination, and from the pole to the zenith or co-latitude, and the included hour-angle from noon H, are given to find the third side, or co-altitude. The well-known formula for this case becomes, by writing sines instead of the cosines of their complements,

$$\sin A = \sin D \sin L + \cos D \cos L \cos H, \text{ and}$$

$$\varDelta^2 \sin A = \varDelta^2 \sin D \sin L + \varDelta^2 \cos D \cos L \cos H. \quad (3.)$$

At the time of the equinoxes, D becomes 0, and the expression of the sun's intensity reduces to $\varDelta^2 \cos L \cos H$. That is, the degree of heat at different places, then, decreases from the equator toward each pole, proportional to the cosines of the respective latitudes. At other times of the year, however, a different law of distribution prevails, as indicated above.

The sun's intensity at a fixed distance being as the sine of the altitude, it follows that the sun shining for sixteen hours at an altitude of 30°, would raise the temperature of a plain as high, as if it shone for eight hours from an altitude of 90°, or from the zenith, since sin 30° is ·5, and sin 90° is 1.

III. Proceeding now to the general problem, it is required to determine the quantity of heat radiated upon a given place at the exterior of the earth on any given day. The quantity radiated at any instant, has already been made known, as $\varDelta^2 \sin A$: hence multiplying the last equation above by the uniform dH, and integrating,

$$\int \varDelta^2 \sin A \, dH = \varDelta^2 \sin D \sin L \, . \, H + \varDelta^2 \cos D \cos L \sin H. \quad (4.)$$

Regarding H as a semi-diurnal arc, the second member will express the daily quantity of heat for a half day, and so for the whole day. Also by integrating between the limits of any two hour-angles H′, H″, the quantity of heat will be found for any assigned part of the day. The sun's declination has here been taken as constant, and it might easily be shown that what the sun radiates by rising earlier than the implied time, is compensated by a uniform change of declination producing an earlier setting sun.

For testing this formula, the intensities were computed for the 15th day of each month, on the latitude of Mendon, Mass., and the results were found to agree very nearly with those observed at that place about *one month later*,* as follows: the observed values are taken from the American Almanac for 1849, and are derived from fifteen years' observations.

Computed values.			Observed values.	Difference.
January 15,	5040	23°.3	24°.3, February 15,	+1°.0
February 15,	7142	33°.1	33°.5, March 15,	+ .4
March 15,	9764	45°.2	45°.8, April 15,	+ .6
April 15,	12574	58°.3	55°.0, May 15,	−3°.3
May 15,	14482	67°.1	64°.5, June 15,	−2°.6
June 15,	15346	71°.1	71°.8, July 15,	+ .7
July 15,	15085	69°.9	68°.9, August 15,	−1°.0
August 15,	13437	62°.3	61°.0, September 15,	−1°.3
September 15,	10860	50°.3	48°.5, October 15,	−1°.8
October 15,	8080	37°.5	38°.9, November 15,	+1°.4
November 15,	5638	26°.1	27°.7, December 15,	+1°.6
December 15,	4510	20°.9	26°.0, January 15,	+5°.1

It may be proper to observe that the preceding formula was divided by sin L, a constant factor; and the numbers in the second column were then successively computed: their sum divided by twelve, gave 10163 as the mean, to be compared with 47°.1, the observed mean at Mendon. Then as 10163 : 47°.1 : : 5040 : 23°.3, Jan. 15, etc. Let it also be observed, that the Mendon values are the monthly means, which do not always fall on the 15th day, but nearly so.

Before applying the formula further, let it be simplified by means of the astronomic equation, $-\cos H = \tan L \tan D$.

Dividing and multiplying the above intensity by $\sin D \sin L$, and at the same time substituting $-\cos H$ for its equal; and $\tan H$,

$$\text{Daily intensity} = \Delta^2 \sin L \sin D\,(H - \tan H). \qquad (5.)$$

This expression is much simpler than the one before employed, and by thus computing the temperatures for different places, and comparing the results with those actually observed, the extent of local causes will be disclosed. The ease with which daily and monthly temperatures may now be computed, it is believed will render this formula valuable in meteorological researches. It is to be mentioned here, that H is an arc of a circle whose radius is 1, which will readily be found by reducing the degrees and minutes, to minutes, and multiplying them by sin 1′, or by multiplying the minutes in time by sin 15′; also using the natural tangent of H, with its trigonometric sign. When the computation is for one place only, sin L being a constant factor may be rejected, leaving,

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* Since writing the above, I find it elsewhere stated that the observed epochs of maximum and minimum temperature in the North Temperate Zone fall about a month later than their expected times at the solstices. The reason assigned for this circumstance is, that for about a month after the summer solstice, the earth continues to receive during the day more heat than it loses at night; and conversely after the winter solstice, it loses more heat during the night than it receives during the day.

$$\text{Daily intensity} = \varDelta^2 \sin D\,(H - \tan H.) \qquad (6.)$$

For example, the results are subjoined for Calcutta, in latitude 22° 35′ N.; the observed temperatures follow the computed, in order:—

January,	59°.2;	65°.1	July,	92°.3;	82°.6
February,	69°.2;	70°.0	August,	88°.9;	82°.9
March,	79°.5;	78°.1	September,	82°.5;	82°.4
April,	88°.0;	83°.3	October,	72°.6;	81°.0
May,	92°.0;	85°.5	November,	61°.8;	73°.4
June,	93°.1;	84°.7	December,	56°.2;	66°.6

From this it appears, that at midsummer about one-tenth of the heat received is carried away by those upward currents which produce the trade-winds, by sea-breezes, and the conducting power of the soil; also a less quantity of heat is restored by the ground, and by winds in mid-winter.

IV. Is the temperature of summer and of winter in the southern hemisphere, the same as with us, at equal latitudes? On this point, the formula $\cos H = -\tan L \tan D$, clearly shows that the length of the day there is the same as in the northern hemisphere six months later. The difference of temperature is therefore limited to the values of $\varDelta^2$. Now the earth being nearest the sun at the northern mid-winter or on January 1st, $\varDelta^2$ is at that time measured by $\frac{1}{(1-e)^2}$; while at mid-winter in the southern hemisphere $\varDelta^2$ is as $\frac{1}{(1+e)^2}$. The difference is $\frac{4e}{(1-e^2)^2}$; or the proportional difference, taking our mid-winter's temperature as 1, is

$$\frac{4e}{(1+e)^2} = 4e - 8e^2 + \ldots = 0{\cdot}06 \text{ nearly.}$$

The southern mid-winter is therefore from 1° to 2° colder; and the mid-summer from 4° to 5° hotter than at an equal latitude in the northern temperate zone, as will appear by multiplying the Mendon values by 0.06. This advantage of the northern hemisphere is due to the advance of the perigee in longitude of 11″.8 per year, which in time will return to the southern hemisphere the advantage we now possess. The summer season of the southern temperate zone being hotter, is also shorter by about eight days than in the northern hemisphere; which difference is ascribed to the more rapid motion of the earth about the perigee.

V. Are the winters now, as cold as at the first settlement of New England? The impression generally prevails that the winters are growing milder, and the spring is later than formerly. Certainly the snows have not been so deep as in the days of Cotton Mather; neither has Boston bay nor the Chesapeake of late years, been frozen over, as far as the eye could reach. So far as this change is astronomic, and not the result of local changes, it may be determined by means of the formula

$$\text{Daily intensity} = \Delta^2 \sin D\,(H - \tan H).$$

In the first place, let it be proposed to ascertain the change of each factor, for the last two centuries, which will refer the formula to the epoch of A. D. 1650, the period of our colonial history. The first factor Δ^2, depends for its value on the anomaly θ, which has an annual change of $11''.8$, and on the eccentricity e, which has a secular variation of 0.000041. Accordingly, introducing these increments into the analytic expression for the inverse square of the radius-vector, which is the value of Δ^2, and developing by Taylor's Theorem, it is found that both sources of variation cannot affect the present values of Δ within the fourth significant figure, in two centuries: hence these sources of change may be safely neglected in the present calculation.

The second factor, $\sin D = \sin \omega \sin T$; where ω denotes the obliquity of the ecliptic, and T the sun's longitude. Since the tropical or civil year is the interval between two successive returns to the same longitude, $\sin T$ ought in the present case to be regarded as constant. But in referring back, ω has a secular increase of $45''.7$, or $91''.4$ in two centuries. Let this increment be denoted by ω'', and the contemporary increment of D by D''. Then developing for the first power of each in the above equation, by Taylor's Theorem, $\cos D \,.\, D'' = \cos \omega \sin T \,.\, \omega''$. Here substituting the value of $\sin T$ from the preceding equation, and dividing by $\cos D$,

$$D'' = \cot \omega \tan D \,.\, \omega''.$$

For the third factor involving the semi-diurnal arc H, astronomy gives $-\cos H = \tan L \tan D$; and developing as before, by Taylor's Theorem, $\sin H \,.\, H'' = \tan L \,.\, D'' \div \cos^2 D$. Substituting for D'' its value found above, also dividing by the preceding equation, $-\cos H = \tan L \tan D$,

$$-\tan H \,.\, H'' = \frac{\cot \omega \,.\, \omega''}{\cos^2 D}.$$

Recurring now to the formula of daily intensity, let it be denoted by S, at the same time developing for the first power of the increments of the two variables, D, H; the resulting increment is

$$\frac{S}{\sin D} \cos D \,.\, D'' + \frac{S}{H - \tan H}\left(1 - \frac{1}{\cos^2 H}\right) H'', \text{ or}$$

$$S\cot D\,.\,D'' - S\tan^2 H\,.\,H'' \div (H - \tan H).$$

And substituting the values of D″, and H″, it becomes

$$S\cot\omega\,.\,\omega'' + S\tan H\cot\omega\,.\,\omega'' \div (H - \tan H)\cos^2 D,$$

which may further be reduced, and dividing by S, the *proportional* secular

$$\textit{Increment of heat} = \cot\omega\,.\,\omega''(H + \tan H\tan^2 D) \div (H - \tan H). \quad (7.)$$

Lastly, restoring the value of S, there results the *absolute* secular

$$\textit{Increment of heat} = \Delta^2\sin D\cot\omega\,.\,\omega''(H + \tan H\tan^2 D).$$

At the time of the equinoxes, D, and with it this increment becomes zero: the greatest values may hence be inferred to prevail near the solstices when D equals ω. For example, computing by formula (7) the proportional increment for December 15, on the latitude of Mendon, and multiplying into the observed number of degrees, it appears that two centuries ago, the mid-winter was colder by 0°.035 F., and the mid-summer hotter by 0°.025 F.: that is, the temperature of the year is growing more equable by slight gradations. It has already been shown in IV, that the year is remarkably so, compared with that in the southern hemisphere.

That the spring is now later, may be accounted for, by the fact that less snow falls, and the ground being uncovered, has, during the winter, radiated more heat into space, and so at the opening of spring is colder than when covered through the winter by a deep stratum of non-conducting snow. And in general, any variation from the mathematical laws here demonstrated, must evidently be looked for, as the effect of cultivation or other terrestrial causes. Besides, as the sun is the great source of the change of seasons, winds, evaporation, etc., these laws, especially the formulas in III, may yet serve as a basis for computing *a priori* the dew-point, monthly humidity, and range of the barometer.

Lastly, among other secondary causes which tend with striking uniformity to counteract extremes of heat and cold, is the vast size of the sun. Were the same amount of light and heat radiated from a body smaller than the earth, the effects would be restricted to a smaller portion of the earth's surface. But as it is, the sun constantly illuminates half the earth's surface and a belt around the earth sixteen miles wide besides, which may be termed 'the zone of differential radiation;' and this is yet very much widened by atmospheric refraction. The effect of this arrangement is evidently to maintain a warmer temperature, besides rendering the transitions more mild and gradual. In conclusion, the evidences of stability of temperature demonstrated in the present article, it is proper to observe, strikingly accord with the authoritative declaration, that, "while the earth remaineth, seed-time and harvest, and cold and heat, and summer and winter, shall not cease."

ART. VIII.—*Notice of Fossil Bones from the neighborhood of Memphis, Tennessee;* by JEFFRIES WYMAN, M.D.

THE specimens of fossils here noticed were kindly sent me for the purposes of description, by Prof. B. Silliman, Jr. They were obtained from the region of Memphis, by Mr. Lawrence of Louisville, and, as is supposed, from the diluvium of the Mississippi. They are representatives of the following genera of mammals, viz., Mastodon, Megalonyx, Castor, Castoroides. They all present points of interest, especially the last three, which belong to genera whose remains are either quite rare or but very imperfectly known.

As yet, our knowledge of the osteology of Megalonyx is far behind that of the allied genera Megatherium and Mylodon; its dentition likewise is but very imperfectly understood. Many fragments of bones and teeth of Megalonyx doubtless exist in public and private collections in this country, which are yet undescribed. Any notices of individual specimens, especially of the teeth, which may be published, will be of great value to the paleontologist in enabling him to form more complete ideas of the organization of this most interesting race of extinct animals as well as of its geographical distribution.

The remains of Castoroides are exceedingly rare and are known only from a lower jaw and some of the bones of the extremities, discovered in Ohio, and described for the first time by Mr. J. W. Foster from fragments of bones discovered by Dr. Dickerson in the neighborhood of Natchez, Miss., and a cranium nearly entire found in the town of Clyde in New York. Although the Castoroides has so wide a geographical distribution, the above constitute the only localities excepting the one noticed in this communication, references to which have fallen under my observation.

The remains of beavers in a fossil condition would seem from the absence of published reports, to be quite as rare as those of the preceding genus. Doubtless many of them exist in cabinets, but have not yet found their way into scientific journals or treatises. Notices of their remains would likewise be of great interest, if for no other purpose than to establish their identity with, or dissimilarity to, the existing species, or to determine the former geographical distribution of these animals on the North American continent. The remains of Castor Europæus, (which by some has been regarded, though on insufficient grounds, as identical with the American species,) have been found in England, generally in peat bogs,* in the marls of Perthshire and Berwickshire in Scotland,† and on the continent in the valley of the Somme

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* Owen. British Fossil Mam. and Birds, p. 190.

† Lyell. Principles of Geology, vol. iii, p. 326.

in Picardy,[*] in the peat of Flanders, and on the shores of Lake Rostoff.

In this country Prof. Spencer F. Baird, in an interesting communication to the American Association for the Advancement of Science, states that in one of the caves in Pennsylvania, he has found the remains of recent beavers associated with bones of recent species of wolves, foxes, bears, rabbits, muskrats, otters, lynxes, panthers, &c., as well as with some bones, about five per cent. of the whole, of extinct species.[†] I have not been able to find any notice of remains of beavers found in the United States in a fossil condition. At present, beavers are confined to the more northern districts, extending as far as the Mackenzie river, lat. 67° or 68°, though we have occasional notices of their existing as far south as the mountains of North Carolina, (S. B. Buckley in Am. Journ. Sc., vol. iii, [2], p. 434,) and in several places in Alabama, (Prof. R. T. Brumley in Am. Jour. Sc., vol. iv, [2], p. 285.) They have been found likewise near Peter's mountain in Virginia, near Ashville, N. C., near Milledgeville, Ga., in Dallas county, Ala., and Flanders county, Ky. Dr. Bachman thinks they formerly existed over the whole continent as far south as the tropic of Cancer.[‡]

No. 1. *Mastodon giganteum.*—This was one of the earlier teeth of a young Mastodon; the longest diameter of the crown was 1·8 inch; its transverse diameter at the posterior edge was 1·6 inch, and at the anterior 1·2 inch, allowance being made for the enamel which is in part deficient. The points of the crown have been entirely worn off, the grinding surface is quite oblique, highest on its outer edge, somewhat excavated, and very beautifully polished. At the posterior inner angle the crown is worn below the level of the enamel, but on its outer face remains of the bases of three ridges are still visible, invested with their coating of enamel.

The remains of two roots or fangs still exist, one of which had been almost wholly absorbed, and the other had the length of an inch, although absorption of its extremity had obviously taken place. The small size of this tooth, together with the existence of but three ridges on the crown, indicate that it was the third tooth in the series.

No. 2. This is likewise a tooth of a young Mastodon, but larger than the preceding. The crown was more worn, its surface less oblique, and more deeply excavated. On one of its margins, vestiges of three ridges remain, and in addition a vestige of a rudimentary fourth ridge. The longest diameter of the grinding surface was 2·7 inches; its larger transverse diameter 2·1, and its smaller 1·8 inch. This, from its greater size, as well as from the existence of a rudimentary fourth ridge, was probably the fourth tooth in the series.*

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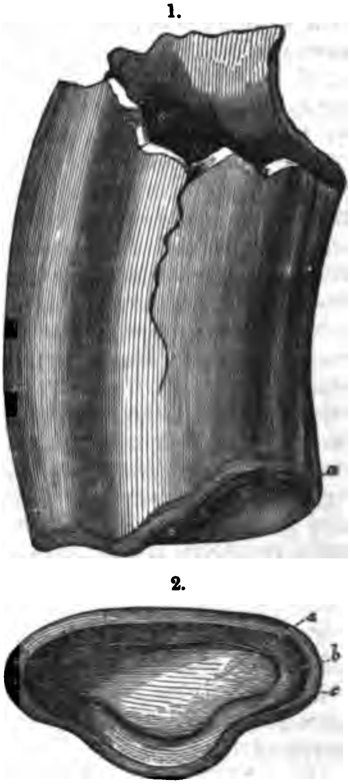
[*] Cuvier. Oss. Foss., tome viii, p. 108, 4th edit., 1836.

[†] Proceedings of Am. Assoc. Adv. of Science at Cambridge, 1849, p. 352.

[‡] Audubon and Bachman. Vivip. Quad. of North America, vol. i, p. 356.

The absorption of the fangs, as well as the grinding down of the crown have been carried so far, that it seems quite probable that it actually had been, or was just upon the point of being shed.

No. 3. *Tooth of Megalonyx laqueatus Harlan.*—This tooth, which is represented of its natural size in the adjoining figures, (figs. 1 and 2,) has the grinding surface perfect, but the opposite extremity is broken off. The form of the grinding portion is elongated oval, has an excavation in the middle, which is continuous with a deep emargination on one of the sides of the tooth (fig. 1 *a*); its longest diameter is 1·6 inch, and its transverse 0·8 inch. On the inner face of the tooth there exists a strongly projecting ridge, which extends from the crown to the base. On the ground surface, three distinct portions may be discovered, viz., 1st, a central one (fig. 2 *a*), consisting of ossified pulp, *osteo-dentine*, 2d, a middle portion (*b*) of *dentine*, and 3d, an outer incrustation of *crusta petrosa*, (*c*). The outer edge of the dentinal portion forms a sharp and prominent ridge around the circumference of the crown; the osteo-dentine having been worn away within it and the crusta petrosa on the outside. At the broken end, the pulp cavity is quite large, having walls of only about 0·2 inch in thickness, and is filled with a compact earthy deposit.



Figs. 1, 2. Upper Tooth of Megalonyx—natural size.
Fig. 1, inner face.
Fig. 2, crown.—*a*. Osteo-dentine. *b*. Dentine. c. Crusta petrosa.

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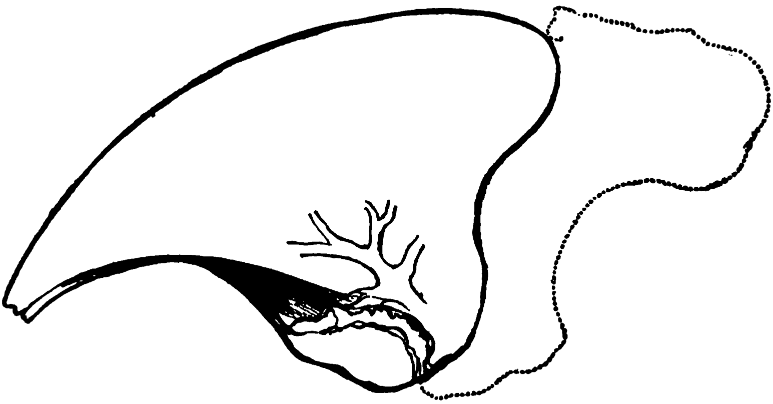
* With regard to the succession of the teeth of the lower jaw of the Mastodon, the following rule holds good: the [illegible] and 2d molars have each two transverse ridges; 3d, three ridges with an anterior and posterior basal ridge; 4th, has three ridges with a large posterior tuberculate talon; 5th, resembles the preceding but larger; 6th, supports four ridges and a small talon; 7th, five ridges and a talon. See Owen's Odontography, p. 620; also J. B. S. Jackson, M.D., Proceedings of Bost.

This tooth resembles that of M. Jeffersonii, figured by Cuvier in the Ossemens Fossiles, in the existence of the lateral ridge, but in its proportions does not materially differ from that of M. laqueatus, Harlan, described and figured in his Med. and Phys. Researches.

No. 4. *An ungueal phalanx of Megalonyx.*—This is imperfect and was from a young animal, as is indicated by the fact the epiphysis forming the articulating surface was not cöossified with the body of the bone, and has been detached. (Fig. 3.) Its general resemblance to the corresponding part of one of the Carnivora is sufficiently strong to render excusable the error of President Jefferson, who referred some remains of Megalonyx to this group of animals.

3.



Ungueal phalanx of Megalonyx. Two-thirds natural size.

An ungueal phalanx of Megalonyx is distinguished from that of either Mylodon or Megatherium, by its greater lateral compression, by its more trenchant upper edge, as well as by the absence of a marked flattening or indentation of this last near the point.* It does not appear that the osteology of the foot of Megalonyx has as yet been much more definitely made out than is its dentition.

The specimen here described differs in its proportions from those of which I have been able to find any figures, it being much higher in proportion to its length, allowance being made for the absence of the articulating epiphysis. Its upper edge is quite regularly curved, rounded near the base, but the half near the apex is trenchant. The point of the bone is depressed, and is separated from the tuberosity by an obtuse angular notch. The under edge of the bone is rounded near the apex, but becomes

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Soc. Nat. Hist., vol. ii, pp. 60 and 140. Dr. Jackson has shown by actual examination that the molar tooth described by Prof. Owen as replacing the first and second milk teeth, and developed in the jaw beneath them in Mastodon angustidens, does not exist in the Mastodon giganteum.

* Owen's Memoir on the Mylodon, p. 106.

flattened and is divided by a prominent ridge, which forming the base of the tuberosity in front, becomes gradually thicker and stronger as it merges into the latter. Laterally near the point and at the base are numerous vascular channels and openings; one orifice of much greater size than the rest, exists on each side just above the tuberosity, and from it several deeply impressed channels extend towards the extremity of the bone. The tuberosity projects from each side of the bone, the upper surface of this projection being excavated into a deep and narrow channel.

In consequence of the absence of a part of this bone, the proportional measurements of the whole cannot be given. Its greatest height from the tuberosity vertically upwards is 3 inches, its greatest thickness is one inch; from the apex to the middle of its greatest vertical diameter 3·5 inches.

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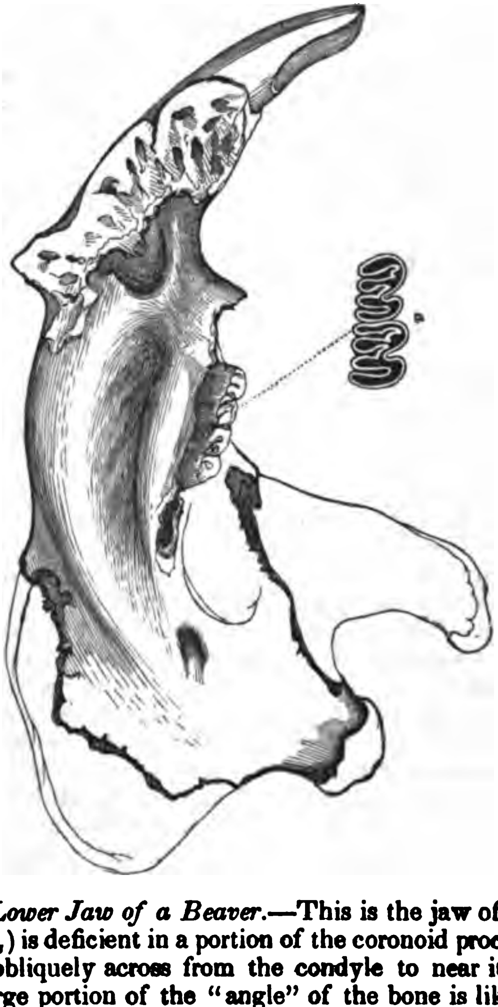


Right Lower Jaw of C. fiber, americanus. Natural size.

No. 5. *Lower Jaw of a Beaver.*—This is the jaw of the right side, (fig. 4,) is deficient in a portion of the coronoid process which is broken obliquely across from the condyle to near its base in front; a large portion of the "angle" of the bone is likewise destroyed, and the first and fourth molar teeth are lost. In its general conformation it corresponds very nearly with that of a specimen of a common beaver (Castor fiber, americanus), from the neighborhood of Moose-head Lake, except that the impressions for the attachments of the temporal and masseter muscles are more strongly marked in the fossil than in the recent specimen. The form of the condyle is somewhat different in the two; that of the fossil specimen being longer in its antero-posterior diameter and resting on a much broader neck; the whole jaw when viewed from above is also more curved, having the form of an italic *f* more strongly marked.

The second and third molars alone exist, and on close comparison present some peculiarities not found in the recent jaw. The anterior fold of enamel in each tooth which is directed across nearly the whole breadth of the crown from the inner to the outer edge, is slightly involuted (fig. 4 *a*,) at the point where it approaches the outer surface, while that of the recent specimen forms a simple rounded termination.

The comparative dimensions of the fossil and recent specimens are as follows:

Length from tip of incisor to middle of condyle,	3·9	inches.
The same in the recent specimen, . . .	3·5	"
Length of the alveolar process for the molars, .	1·5	"
The same in the recent specimen, . . .	1·3	"

No. 6. This is an alveolar portion only, of a left lower jaw, and contains the 2d, 3d and 4th molars, which gradually become smaller from the second to the fourth. The teeth of this specimen present the same complication of the folds of enamel as in the preceding one.

No. 7. Is a fragment of the left incisor tooth of a beaver, but both extremities are broken off. In its dimensions it corresponds with the same tooth in No. 5, but is of much darker color and appears to have come from a different locality.

Remarks.—The differences between the teeth of the fossil and recent specimens above referred to, would, in the minds of many naturalists, be sufficient grounds for the establishment of an additional species. I have made comparisons with only two recent specimens, and do not consider myself justifiable in forming a new species, until by a careful examination of several jaws, the limit of natural variations be determined. It is not improbable that the above differences come within that natural limit, or may be a sexual peculiarity. It is certainly a matter of some interest and importance to determine if the fossil and recent species are identical.

No. 8. *Castoroides Ohioensis*, *Foster.*—The most interesting specimen from the Memphis collection is a large fragment of the right half of the lower jaw of this recently discovered species, a species not only interesting for some of its osteological peculiarities, but for the fact of its being the most gigantic member of the order of Rodents hitherto discovered, whether recent or fossil.*

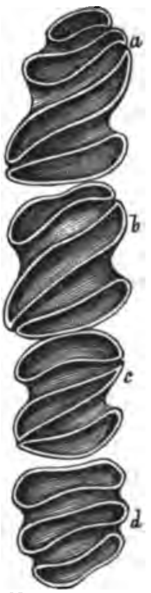
The present fragment is 7·3 inches in length, though the condyle, coronoid process, "angle" and the whole of the under portion of the jaw have been broken off—a portion of the notch (sigmoid) between the condyle and coronoid process remains. The four molar teeth with their alveolar dependencies are entire, and a large fragment of an incisor tooth is still preserved lodged in its partly destroyed alveolus. The jaw is larger and somewhat more massive that the one described by Mr. Foster, but in other respects does not appear to differ materially from it. An approximation to the proportional dimensions of the three jaws which have been noticed may be deduced from the following measurements.

Length of the grinding surface of the molars in

The specimen from New York,	2·7½	inches.
" " " Ohio,	2·8	"
" " " Memphis,	3·1	"

In some other measurements the Memphis specimen exceeds the preceding ones in the same proportion.

5.



Molar teeth of Castoroides Ohioensis, right side of lower jaw,—natural size.

The grinding surface of the molar teeth taken together is somewhat concave in the direction of its length. The anterior tooth rises nearly three-fourths of an inch above the alveolus, the second and third sink nearly to its level, but the fourth is a little more elevated. Each tooth consists of a series of elongated elliptical plates or laminæ of enamel which include the dentinal portion; they are directed obliquely across the crown, and cemented together by a layer of crusta petrosa. The front tooth (fig. 5*a*) which is the largest, has four laminæ, the first quite small and the third the longest and the most oblique. On the outer face there is a deep groove between the third and fourth plates, and on the inside one between the first and second, another between the second and third, and a very indistinct one between the third and fourth. The second and third grinders have but three laminæ, and their grinding surface has the outline of an hour glass or a figure 8, in consequence of the existence of but a single groove on the outer and on the inner face. In both of these teeth the first and third laminæ are parallel to each other, but the second makes an angle with them, so as to touch the first on the outside, and the third on the inside of the tooth. The outer groove is situated between the second and third plates and the inner between the second and first, but in consequence of the obliquity of the third plate, are nearly opposite. The fourth tooth is the smallest, the laminæ are all nearly parallel to each other and the lateral grooves are much less deep than in the preceding teeth.

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* This species was first recognized and described by Mr. J. W. Foster in Am. Jour. Sci., vol. xxxi, p. 80, also in the second Report of the Geological Survey of Ohio, p. 81. A cranium nearly entire was subsequently discovered in Clyde, N. Y., and was described and figured in the Boston Journal Nat. History, vol. v, p. 385.

It does not appear from any examination which I have made of the fractured teeth, that the different laminæ are united together at their bases by a continuous layer of enamel passing from one plate to the other, as is the case in the teeth of the elephant. Each tooth appears to be made up of a series of flattened dentinal columns invested with enamel and simply cemented together by crusta petrosa.

The incisor tooth in a transverse section is of a triangular form, with rounded angles; its inner face smooth and concave, its anterior convex and fluted with well marked parallel grooves, and its posterior convex and smooth. The double curvature of this tooth is quite remarkable; when viewed laterally its curve is that of the segment of a circle; when viewed from below it has a curvature in a plane at right angles to the preceding, which curve as is shown very distinctly in the cast of Mr. Foster's specimen is in the form of an *ſ*, as is the case in the beaver and many other Rodents. If both of these curves were continued they would produce a spiral. It is well known that the incisor teeth of Rodents are constantly wearing away at the apex, and are as constantly replaced at the base, so that if we would suppose the growth continued through life, and that no abrasion took place, there would be eventually produced a spiral of several revolutions in the form of a cork-screw. We have an approximation to this in Rodents which have lost one of their incisors, and in whom the opposite one no longer worn off, has continued to increase in length sometimes forming more than one revolution.*

The remains of the Castoroides though they have seldom been found, have nevertheless as already stated, a wide geographical distribution, having been discovered in New York, Ohio, Tennessee and Louisiana, and in all these localities except New York, have been associated with the remains of the Mastodon; and Mr. Hall refers the deposit in which the New York specimen was found to the same period as the deposits in which the Mastodon has been discovered in the neighboring portions of that state.†

It is also interesting to notice the existence of the remains of Castor and Castoroides in the same localities, one of which continues to the present period, and the other, the gigantic representative of the Rodents, has disappeared with the corresponding one of the Pachyderms.

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* See Catalogue of Cabinet of Bost. Soc. Med. Improvement, specimens 527 and 588.

† Notice of the Geological position, and an anatomical description of the cranium of Castoroides Ohioensis.—By James Hall, Esq., and Dr. J. Wyman. Boston Journal of Nat. Hist., vol. v, p. 385.

Art. IX.—*On the Geological Structure of Keweenaw Point;* by Dr. C. T. Jackson, U. S. Geologist.

(From the Proceedings of the American Association, 2nd meeting, held at Cambridge, 1849, p. 288.)

This remarkable promontory extends from the south side of Lake Superior nearly into the middle of the Lake, from 46° 40′ to 47° 29′ north latitude, and is comprised between 87° 55′ and 89° 30′ west longitude. Its general direction is to the E.N.E., in the line of the trend of the great dikes or masses of Trap rocks which form its central ridges.

The surface of the country is broken and rolling, and some of the hills attain an elevation of nearly 900 feet above the lake level. Although but few species of rocks exist on this promontory, they present phenomena of remarkable scientific and practical interest. On the immediate coast, excepting at a few points, the first rocks that meet the eye of the geologist are a coarse conglomerate, made up of large rounded and smooth pebbles of red porphyry quartz, altered slate and sandstone, masses of epidote rock, syenite and hard greenstone trap, mostly of the porphyritic variety, and regular strata of fine grained red and grey or mottled sandstone, devoid of any fossil contents.

The direction of the strata of sandstone and conglomerate is parallel to the line of uplift of the trap rocks, or E.N.E., W.S.W. Its dip is toward the W.N.W., at various angles, being greatest near the trap rocks, which come between their strata and divide the great masses of sandstone throughout the whole length of the promontory. The strata remote from the trap on Keweenaw Bay, and the opposite side of the point, at the portage, are horizontal or but slightly waving, while near the trap rocks the dip of the strata is generally as high as 30°, and sometimes more. The conglomerate rock is limited to the borders of the trap range, and is of the same geological age as the finer grained sandstones, and alternates with them.

At the line of junction of the trap rocks and sandstones, the sandstone and trap are interfused, producing that singular and very important metamorphic rock amygdaloid, a rock closely resembling the vesicular lava of volcanoes, but having its cavities filled with a great variety of curious and interesting minerals.

In the memoir published by Mr. Alger and myself on the mineralogy and geology of Nova Scotia, in the American Journal of Science, vols. xiv, xv, 1828, will be found an account of the origin of amygdaloidal rocks, like those of Keweenaw Point, and it may not be uninteresting to compare the trappean ranges on Lake Superior with those of Nova Scotia. On inspection of the map it will be seen that the great trappean band on Keweenaw

Point is parallel with that on the borders of the Bay of Fundy in Nova Scotia, and it will be further noticed on examination of the geology of these distant regions, the conditions of the rocks are similar, if not identical. The trap of Nova Scotia, like that on Lake Superior, protrudes from below the red sandstone, supposed to be the new red, and passes between the strata in the line of least resistance. Amygdaloid, with species of minerals similar to those of Lake Superior, excepting Prehnite, which is rarely found in Nova Scotia, exist also at the line of junction of the trap rocks and sandstones of Nova Scotia. Native copper occurs in the amygdaloid of both places, but is more commonly found in the trap tuff of Nova Scotia, while it occurs more abundantly in the amygdaloid of Lake Superior. Heulandite is rare in the Lake Superior trap rocks, while it is extremely abundant in Nova Scotia, but the other minerals are of the same species in both places.

It will be observed on examination of the geological maps, that the same gentle crescentic curving of the trap bands towards the northwest was noticed in both countries, a fact also recorded by Dr. Percival and Prof. Rogers, in their reports on the geology of Connecticut and New Jersey.

General geological laws seem to have prevailed in all the regions where trap rocks have burst through sandstone, the effects of heat being recognizable, and proportional to the relative masses of intruded rocks.

It cannot fail to strike every geologist familiar with rocks of igneous origin, and their effects on sedimentary strata, that the history of the origin of trap rocks is indelibly recorded, and that they are really lavas that have risen from the interior of the globe through fractures in its crust, taking the line of least resistance by passing between the strata.

By the influence of heat the sedimentary strata were interfused with the igneous rocks, and it is a singular fact that amygdaloid is most abundantly produced by the action of trap rocks on sandstone, and that copper is the most usual metal found in the fissures, amygdules, and pockets of the resulting amygdaloid.

True workable veins of native copper in this class of rocks had not been described, so far as I know, anterior to my researches on Lake Superior, and it was regarded as contrary to all experience that this metal should thus occur in quantities sufficient for profitable mining. The only locality where native copper has been mined to any extent, is in Siberia, but the metal is not in trap.

Having satisfied myself of the fact that adequate quantities of the metal did exist in veins in the amygdaloid trap of Lake Superior, I ventured to recommend the opening of mines on Keweenaw Point, on and near Eagle River, and the result has proved that native copper veins can be profitably wrought. I mention this fact now in order to recall to your minds the objections that were made to my views on this subject at our meeting in New Haven, in 1845. The predictions I then made are now fully verified.

Nature of the Veins in the Trap rocks.—There are two classes of veins known to miners on Lake Superior, viz.: 1st. Those running with the "country," or parallel to the course of stratified rocks through which the trap rocks pass—veins that are sometimes called beds, or interstratified masses. And 2nd. Those which cross the "country," or cut transversely at various angles the line of direction of the strata.

These last are called true veins, and are the only ones on which miners have thus far placed reliance as to their continuing rich to any considerable depth. I do not regard the question as fully settled by experience in this district, that mining should be confined to the transverse veins, for there is reason to believe that both classes of veins are of the same origin, and no facts have yet been adduced to prove that veins running with the "country" cannot be advantageously wrought. On the contrary, it is known that large quantities of native copper are raised from this class of veins on the Ontonagon River, and it is probable that some on Isle Royale will ultimately prove valuable. A few good practical experiments in mining will settle this mooted point in practical geology. It is obvious, since the trap rocks are not really stratified, that this class of veins cannot be correctly denominated interstratified, though they may be imbedded.

The first class of veins run, as will be understood by what I have previously said, nearly E.N.E., W.S.W., varying with the flexures of the line of junction of the trap and sandstone, and are included between the two rocks in amygdaloid or in epidote, this mineral being the most usual gangue or matrix of the copper. Regular walls of solid copper of some inches in thickness, have been observed in one of the new mines opened in the Ontonagon River, and sheets of considerable size have been found in the east and west veins on Isle Royale.

Mining operations are now in progress to test the permanency of these veins; we shall know in a year or two the results.

The second class or tranverse veins run generally in a course N. 26° to 30° W., S. 26° to 30° E., and consequently cut across the line of direction of the trap rocks and adjacent strata. They are especially rich in the amygdaloidal trap, and thus far have not been profitably worked beyond its limits. In the hard trap rock they are pinched or become narrow, thin plates of metallic copper filling these seams in the trap. The "veinstone" contains the following species of minerals: prehnite, calc spar, laumonite, leonhardite, quartz, datholite, chabasite, mesotype, apophyllite, feldspar, analcime, and wollastonite.

The most common veinstone is prehnite, which occurs in regular symmetrical veins, the prehnite encrusting the sides of the fissures and closing in the middle of it by crystallized botryoidal surfaces. At the surface these veins are rarely more than six inches in width and containing only minute scales of metallic copper, the presence of which in decomposed veins is most readily detected by spots of green carbonate of copper, derived from exposure of the metal to the air and water. These narrow and poor veins of prehnite enrich in copper as they descend into the rock, until at last the prehnite gives way to copper and its space is entirely occupied by it, a thick vein of solid copper filling the fissure, while the prehnite was either absorbed by the rock, or the condition of the rock was such that it could not be formed.

At the Cliff Mine of the Boston and Pittsburg Mining Company, the vein at the top of the cliff consisted of prehnite, containing only minute scales of copper, and was only six inches wide, but it was found on descending that this vein widened, about two hundred feet lower down, to eighteen inches, and lower still it had widened to two feet, and was charged with from five to thirty per cent. of metallic copper, and some particles of silver. The average yield of a large sample of the vein at the surface was found to be $5\frac{6}{10}$th per cent. of copper, and it was estimated that the ore could be practically "bucked" or picked up to 15 per cent.

The width of the vein was estimated to be three feet at the base of the hill, where it was still concealed from view by the soil. On driving a level into the cliff and one at the base of the hill, the vein was proved to be much richer than at the surface, and on sinking a shaft to the depth of 226 feet below the base of the hill, it exposed sheets of copper varying in thickness from a few inches to three feet. These masses of copper filled the vein, and the prehnite and other zeolitic minerals disappeared. By carrying forward levels at the proper points, sixty feet below each other, and by stoping out the backs of the levels, large flattened ellipsoidal masses of copper were exposed, and removed by heavy blasts of gunpowder. These masses were then cut up by mortising out channels through them by means of steel chisels, driven by a heavy sledge hammer.

Some idea may be formed of the rapid increase in richness of this lode by comparing the poor prehnite vein at the top of the hill with the ponderous masses of pure copper that are now cut up in the mine below. One mass of pure copper extracted while I was on the survey, weighed eighty tons, and other masses probably of equal magnitude were in process of being uncovered.

Taking into account the height of the cliff in which the vein is seen, and the depth of the shafts at its base, we have the vein proved 526 feet deep, and thus far it has been steadily enriching, and has surpassed the most sanguine expectations of all the miners and geologists who had examined it.

Already this mine sends to market nearly a thousand tons of copper ore per annum, the ore being estimated to contain sixty per cent. of pure copper after it is cleansed of the adhering rock. This mine, it is understood, has paid for itself and made a dividend of ten dollars per share to its owners.

It is highly probable that other mines on Keweenaw Point, if wrought with the same energy and skill, would prove equally valuable, but thus far no mining equivalent to that of the Boston and Pittsburg Mining Company has been attempted, and it is difficult to find a miner so competent to the task as Capt. Jennings, the Cornish miner, who has had charge of this remarkable mine. I exhibit to you a profile and plan of the mine, in which all the excavations are fully delineated.

Among other promising mines are the North American, the Copper Falls, the Northwest, and the Phenix, all of which have been sufficiently proved to warrant the belief that they can be advantageously wrought, but still it must be remembered that even in the best known mineral districts, mines frequently fail to prove profitable from causes that are not at once foreseen. The North American Company's mines are situated very near the Cliff mine, on the west branch of Eagle River, and are now wrought with energy, and give promise of success nearly equal to that of the Cliff mine before described. The veins are similar in their nature and in their contents, so that I need not describe them.

The Copper Falls mines have been opened to a considerable extent, and from one of the veins a single mass of copper was taken that weighed eight tons. It was sawed into pieces and sent to market. I exhibit to the section a specimen sawed from this mass. It is perfectly pure copper, and as dense as the purest hammered copper of commerce, showing its perfect fineness. There is a considerable proportion of native silver mixed with the copper of this mine, and in the green veinstone, a specimen of which I lay before you. Silver is found also in most of the copper mines of the lake, and frequently in sufficient quantities to be of commercial value. It is most curiously united with the copper, and in some of the pieces I lay before you, the metallic copper is actually porphyritic with masses of silver, and yet the silver is absolutely pure, and the copper is also pure, there being no alloying or chemical union, but a mere metallic cementation at the line of contact. This phenomenon is seen in all the localities on the lake where native copper and silver occur together, and this state of the metals must have arisen from a common cause acting in every one of the veins. It is not capable of being explained in the present state of chemical and geological knowledge, and is a subject for experimental research. The solution of this question will lead to an explanation of the origin of the native copper and silver veins, the rationale of which we have not yet reached.

All the experiments I have devised and executed, to discover the cause of the separation of the copper and silver, as seen in these specimens, have given negative results. The experiments were made on fused alloys of silver and copper. The metals did not separate by galvanic agency. Little has yet been done towards extensive working of the Northwest Company's copper mine. It is situated a few miles from Eagle Harbor, and several rich veins of native copper, with some native silver, have been discovered and wrought to a small depth. The want of confidence in this new kind of mining prevents the investment of sufficient capital and the employment of a sufficient mining force to work the mines. I am confident, that, with capital and skill, this company's mine might soon be rendered profitable.

The old Lake Superior Company, the first organized for mining on Lake Superior, was unsuccessful in its first operations from several causes, among which the want of miners capable of carrying on the work in a proper manner was the chief; and it should be remembered that mining for native copper was, at that time, a new business to both English and American miners. Numerous changes were made and many new shafts were sunk, but no regular preconceived plan was ever carried out, and hence the mines are in a neglected state. Much allowance should be made for the newness of the enterprise, the wilderness state of the country, and want of skill in the miners hastily collected from districts wholly unlike the one they were sent to explore. There was also an erroneous opinion prevalent among many of the original stockholders that mining could be made profitable from the outset,—a most fallacious idea. The company soon closed up its mining operations, and I have heard that a new organization has been since adopted, and it is hoped, if mining operations are again begun, a regular system will be pursued, modelled after the plan of the Boston and Pittsburg Company's workings. The Lake Superior or Phenix Company's veins are rich in native copper and silver, and although the leader or prehnite vein is but a few inches wide, it will doubtless lead to a solid copper vein, like those heretofore described. Masses of pure copper, of large size, weighing some thousands of pounds, were obtained from an ancient ravine or excavation that had been worn out by the river running over the vein, and large pieces of silver were also found. These show the contents of the lode in the true vein. Most of the work heretofore executed at this mine has been done in the western wall of the vein and not in the vein itself. To the company owning the Lake Superior mine is due the credit of the earliest mining enterprise on the Lake, and those who have followed after them should remember that they opened the way and introduced the business of mining into the then unbroken wilderness of Lake Superior.

It is still a question among geologists and miners whether veins were filled by igneous injection or sublimation, or by aqueous and galvanic deposition. This question is one of very great scientific and practical interest, and is exceedingly difficult to answer so far as relates to the native copper and native silver of Lake Superior.

The objections to the igneous origin of native copper are, 1st, that the metal bears the imprint of crystals of prehnite, as seen in the specimen I lay before the section, and we cannot account for the fact that this zeolite was not rendered anhydrous by the molten copper. 2dly, that if the copper was melted, since its fusing point is much higher than that of silver, that the silver is not alloyed with the copper, but is separate from even a trace of it in chemical combination, though small particles and large lumps of silver are mixed and united with the metallic copper.

These objections are equally strong against the theory of sublimation of the copper, and since silver is not volatile at the highest temperature of our furnaces, we could not account for the presence of that metal by a simultaneous sublimation of the metals.

Against the theory of its aqueous deposition, or its origin from any solution of copper, it may be urged that if the metal was in chemical solution, no material capable of causing its decomposition with the deposition of the copper in a metallic state exists in the vein, and no salt, if any supposed acid solvent, which would result from the decomposition of its combination, exists in the vein. Again, it would be impossible for the chasm to contain a sufficiency of any copper solution, however concentrated, to produce the solid metallic copper filling the fissure, for, as before observed, the masses of copper are from a foot to three feet in thickness, and occupy the whole space of the sundered rock.

Galvanic segregation it has been supposed would explain the origin of these copper veins. But we may ask, from what was the copper segregated? It is impossible for galvanism to create the metal from the ingredients of trap rocks, or sandstone; and we can hardly imagine any arrangement of the rocks that would produce a galvanic battery with its poles so arranged as to effect the deposition of a vein of solid copper two or three feet in thickness.

It is well known that the trap rocks are magnetic, and that they possess polarity at the surfaces of disjunction. This has been fully substantiated by the researches of Dr. Locke and others on the Lake Superior mineral lands, but this magnetism is obviously the effect of the earth's inductive magnetism exerted on the very large proportion of magnetic iron ore entering into the composition of the trap rocks, a quantity so large that I have seen pig iron made directly from those rocks by fusion in a blast furnace, about twelve per cent. of iron being reduced from it; and we know, from the experiments of Dr. Locke, that even fragments of the trap rock are both magnetic and polar. It remains to be proved that there are any *electric* currents in the native copper veins, for such currents are by no means proved by deviations of the magnetic needle, which are doubtless produced by the magnetic polarity of the trap rock itself.

The occurrence of bright scales and perfect crystals of native copper in perfect crystals of prehnite, datholite, calc spar, and quartz, would seem to indicate a simultaneous deposition of the copper and those crystallized minerals including it, or that they were impregnated with native copper by sublimation immediately before the injection of the principal copper vein took place. If we could admit the igneous formation of zeolites, and of calc spar, there would be less difficulty in accounting for the veins by sublimation or injection, or by both methods, but this chemists will not readily admit, for the zeolitic minerals are generally hydrous.

It is also a question whether the native copper in the amygdaloid was derived from the interfused sandstone, or was mechanicically brought up with the trap rock. It has been imagined, that since the sandstone is made up of the detritus of more ancient rocks which might have contained copper ores, that the copper ore being deposited with the sand was reduced by the action of the trap. This idea would be plausible, if it could be shown that the sandstone in the vicinity of the trap contained copper in a sufficiency to account for that in the amygdaloid; but such is not the case. It has been said that local deposits of the ore might have taken place in portions of the sandstone strata, and that the trap rocks came up and reduced it. This would be imputing a most remarkable degree of intelligence to the trap rocks, that they should know exactly where the copper ore was deposited, and come up at those places expressly to smelt it! I must confess that I cannot attribute the origin of the copper to any other causes than those which produced the trap rocks themselves, and that the copper came from the molten interior of the earth seems, at least from what we know of igneous agencies, to be most probable. There are veins in the conglomerate rocks which are filled with calcareous spar, containing crystals of copper, some of which will weigh half a pound, and are generally in the rhombic dodecahedral form. One of the calc spar veins at Agate Harbor has yielded masses of copper weighing several hundred pounds.

At Copper Harbor, a large vein of solid black oxyd of copper was found in the conglomerate rock. This ore is not known to exist in any considerable quantity elsewhere. The ore in the vein was fourteen inches wide, and for a short time the mine furnished a good supply of copper ore, yielding about sixty or seventy per cent. of metallic copper. It was soon exhausted, a bed of fine grained sandstone cutting off the copper vein, the calc spar only continuing in the sandstone below. Among the masses of black oxyd of copper brought from the mine at Copper Harbor, Mr. J. E. Teschemacher discovered regular cubic crystals of the ore, crystals which show that the ore is not a mere mechanical mixture of copper smut with earthy matters for a cement, as some have supposed. A pure specimen analyzed in my laboratory yielded 79·86 per cent. of copper.

There are also found at the Copper Harbor mine, chrysocolla, or hydrous green silicate of copper, and the black silicate, which contains a less proportion of water. These ores, we can easily conceive, might be produced by the decomposition of a solution of copper by the action of a hot solution of lime. The black oxyd may have been derived either from a solution, or from igneous sublimation. We know that black oxyd of copper is sublimed from the crater of Vesuvius, and is deposited in fine splendent scales like specular iron ore in the lavas.

Chlorid of copper is very volatile, and is sublimed in the crater of Vesuvius. It is also known to be volatilized in the blast furnace. The experiments of Mr. Frederick W. Davis, at the Point Shirley copper works, have fully demonstrated the fact that a considerable proportion of copper is lost by sublimation from copper ore, containing the chlorid of that metal.

These facts may at some future day serve to explain some of the phenomena relating to the formation of metallic veins. At present there is no part of geological science so little understood as the theory of veins, and on this account I am desirous of calling the attention of the Section to this subject.

With respect to the age of the red sandstone of Lake Superior, I would remark that there have been and still are differences of opinion. No distinct fossils having been found in it, the usual index for fixing the geological age of stratified rocks is wanting.

From the mineralogical character and the geological associations of the rocks, their parallelism to those of Nova Scotia, and their mineral contents, I was led in 1844, to suggest the identity of the two formations, as contemporaneous, and regarded the Lake Superior sandstone as the new red, or at least as of the same age with that of Nova Scotia, New Jersey and Connecticut. This idea I still favor.

During the last year the linear surveyors, who were engaged in subdividing townships on the southern portion of Keweenaw Point, discovered a large protruding mass of Silurian limestone, around which the sandstone strata are horizontal. My assistant was sent to examine this limestone, and states that its strata lines dip about 30°. A fragment of a fossil, probably a Pentamerus, was also found in the limestone. These facts would seem to prove that the sandstone is above the Silurian limestone, and consequently that it is either the old or the new red. The absence of fossil shells in the sandstone would lead us to conclude that it does not belong to the old red, and consequently we are led back to my original opinion, as published in the American Journal of Science, in 1845, that the Lake Superior sandstone is of a later date, and is probably the new red.

This opinion was also expressed by Monsieur De Verneuil, during his visit to the Lake in 1846, but I do not know from what data his opinion was formed. It has been asserted that the Lake Superior sandstones pass beneath the Silurian rocks, but I do not think the fact has ever been observed.

Isle Royale.—This island is situated on the north side of Lake Superior, in latitude 48° North, longitude 89° West. It is about forty miles in length, and five or six miles wide. It presents a broken and rugged outline on its coast and is deeply indented by long and narrow inlets and bays, all of which are parallel to the ranges of the trap rocks which constitute the ridges traversing the island throughout its length. Several small lakes are also seen lying between the trappean hills and coinciding with their line of bearing.

The general direction of this island is parallel to that of Keweenaw Point, and the trap rocks are of the same geological age and have uplifted the sandstones of the same epoch.

On the southwestern end of the island the fine red sandstone strata are seen near Card's Point, and they extend along the coast of Siskawit Bay to Epidote Cove, forming gently sloping sheets extending out into the lake to a considerable distance. Conglomerate rocks border the coast nearly to Rock Harbor and lie next to the trap. The inland boundary of the sandstone was ascertained by my sub-agents to be parallel to the coast line where it is exposed. About one-fourth the area of the island is sandstone and conglomerate rock. All the rest of it consists of trap, which forms ridges attaining an elevation of from three hundred to five hundred feet above the lake, and extending in a broken line throughout the whole extent of the island. In some places isolated masses of trap rocks form tall towers standing like high chimneys on the hill sides; in others, picturesque islands covered with dark spruce trees are seen jutting out on the coast, or standing like watch towers at the entrance of the harbors.

Isle Royale was better known to the Indians as a good place for catching Siskawit than as a mining region; and it is probable that the name *Menung*, signifying a good place, refers to the fisheries, but it is certain from the "Relacions" of the Jesuit fathers, that they were aware of the existence of an abundance of copper boulders upon its shores.

Numerous explorers had visited Isle Royale anterior to my survey, but mining operations had not been entered upon to any extent on account of the difficulties arising from some official misunderstanding as to permits for leases. Dr. Locke had selected some veins and beds of copper for the Ohio and Isle Royale Company, and explorations were going on to determine the probable value of several veins.

There are two kinds of veins on this island, as before mentioned. The widest are those near Rock Harbor. They are thick beds of solid epidote rock filled with small spiculæ of copper, there being from eight to ten per cent. of the metal in the gangue. These beds dip but slightly from the horizon, rarely more than 15 or 20°, and crop out on the south side of the island a few feet above the surface of the Lake. Beneath the copper-bearing bed of epidote, which is a foot in thickness, is a large bed of barren epidote rock, six feet thick, and very hard. Trap rocks overlie the whole, forming bold precipitous shores. No mining operations have yet proved the extent of these cupriferous epidote rocks, but they are exposed to a sufficient extent to render it probable that they will prove of value.

Another set of true veins occur, cutting the trap rocks nearly at right angles, and traversing the country. These veins are generally narrow, and are filled with datholite, prehnite, and native copper. The datholite is very abundant, and may prove of economical importance either as a flux for copper ores, or as a material suitable for the manufacture of borax. One of the locations of the Ohio and Isle Royale Company was named, by Mr. J. H. Blake, Datholite, on account of the abundance of that mineral in the veins of copper.

At Todd's Harbor, mines have been opened, and a considerable quantity of native copper has been obtained by Mr. McCulloch. Other veins have been opened at Scovill's Point, but as yet none of the veins on the island have been sufficiently proved to authorize the erection of permanent works for mining and smelting. One vein of each kind, opened to a considerable depth, would give much valuable information concerning the permanency of the veins, and determine whether they widen and enrich or not.

It is extremely difficult for any one to decide absolutely on the value of a metalliferous vein, and it is only possible to form an approximate estimate where all the conditions of the problem are capable of being determined, and it is rarely the case that we have any thing more than a superficial view of the contents of a vein. It has been proved by a writer in the French Annales des Mines, that in Germany and France only one-twentieth of the mines surveyed and recommended by the Royal Engineers of mines have paid a profit to the stockholders, hence we should remind persons about to engage in mining adventures that their chances of success are only about five per cent.

When a mine is well proved it generally holds good veins, rarely running out in depth unless the rock changes, and then the vein also generally alters.

How far the native copper of the Lake Superior mines continues in depth is yet unknown, but the veins if they traverse sandstone strata will certainly change in that rock, and experience has thus far shown that the copper diminishes in that portion of the vein which traverses the sandstone. This has been fully proved at the Copper Falls mines, where a bed of sandstone, seventy-two feet in thickness, has changed the character of the lode where the vein passed through it, calc spar filling the chasm and the copper nearly disappearing in the veinstone.

It was hoped that the vein would enrich after it had passed through the sandstone into the nether bed of trap rock, but it was found to be diffused into string veins of little practical importance. Owing to the limited extent of the amygdaloidal trap, the true or transverse veins are not of great length, two thousand feet being perhaps an approximation to their linear extent, though it is possible that some may be longer. The idea of tracing a vein by its course over an extensive tract of country has proved fallacious on Lake Superior, and only the geological character of the country can be relied upon as a tolerably correct guide. The river beds, depressions in the soil, corresponding to the usual direction of the veins, afford the best facilities for finding veins, and by means of the solar compass and magnetic needle, lines of contact of the sandstone and trap may be readily found, and the amygdaloid is formed at those junctions. It was observed in my first visit to the Lake, that the productive copper veins occur where there are the greatest number of alternations of sandstone and trap rocks, as shown by the diagram exhibited to the Section. No less than six alternations of these rocks were observed near Copper Falls and Lake Superior mine in my surveys during the summers of 1844 and 1845. Subsequent researches have confirmed this observation.

From these data we should expect copper veins at the line of contact of the sandstone and trap on Isle Royale, but thus far in only a few places have the rocks been uncovered in the vicinity of the junction—some loose masses of native copper found on the shore of Siskawit Lake and the veins at Datholite Cove being the only facts obtained in confirmation of this opinion.

In the hard columnar and compact trap there is little hope of finding valuable veins, for only narrow and tightly pinched seams of copper have thus far been found in these rocks.

On the Ontonagon river there are several veins of copper that run with the "country." They are now in course of trial, and it will soon be ascertained whether they can be profitably worked or not. The opinion of a practical miner, on whom I place reliance, is favorable to some of these mines. It was my intention to have examined them myself, this summer, before drawing up my report, but it has been ordered otherwise.

Rich ores of iron have been found in inexhaustible quantities in the district of country extending from the Menomonee River to Dead River. I have not had an opportunity of examining the localities myself, but I had obtained rich specimens of the ore from the Menomonee river, in 1844, through the agency of M. Barbeau, who obtained them from the Indians, and in 1845, the Indian chief who furnished those specimens, guided Mr. Pray to the Iron Mountain near the Menomonee River. During the past summer this locality has been also examined by one of my assistants.

Art. X.—*Analysis of Algerite;* by Richard Crossley.

Read before the Bost. Soc. Natural History, by C. T. Jackson, April 17, 1850.

This mineral having been already described in this Journal for July, 1849, vol. viii, No. 22, renders it unnecessary to say much more on this head. I have in addition, however, to remark that many of the crystals are encrusted with idocrase, and in some instances are penetrated, so much so that it required great caution to secure such portions as were free from that mineral. The crystals being cleared of decomposed parts were broken to coarse fragments, and the honey-yellow pieces reserved for examination.

Before the blowpipe, alone, it readily fuses with intumescence to a white blebby glass: with soda it gives a dirty-white slag: with borax and phosphorus salt it gives a clear bead faintly tinged by iron and leaves a siliceous skeleton. Heated in a closed tube it gives off water which reacts feebly alkaline, and the powder, at first of a light buff color, darkens and assumes a brownish tinge. About 1 gramme of the coarse fragments gave a spec. grav. of 2·78. It is a little harder than calc spar, from 3 to 3·5.

Nearly 2 grammes of the mineral were very finely powdered, intimately mixed and divided into two portions. One was appropriated to the determination of the water and the other for the estimation of the carbonic acid. This latter portion was then *attacked* by a mixture of sulphuric and hydrochloric acids. The usual mode of analysis was afterwards pursued, and there resulted:—

Silica, ...	51·27
Alumina, ...	23·10
Peroxyd of iron, ...	1·48
Magnesia, ...	5·18
Carbonate of lime, ...	4·21
Potash, ...	9·97

To ascertain the purity of the silica it was fused with carbonate of soda and was found to contain 1·31 per cent of alumina. A second *attack* by acids would doubtless effectually decompose this mineral. Correcting the silica and alumina and adding the water determined on the first portion, the composition of the selection made will be thus:—

Silica, ...	49·96
Alumina, ...	24·41
Peroxyd of iron, . . .	1·48
Magnesia, ...	5·18
Carbonate of lime, . . .	4·21
Potash, ...	9·97
Water, ...	5·06
	100·27

The amount of carbonic acid directly estimated agreeing so nearly with that in the carbonate of lime obtained, evidently shews that the lime is not a constituent of the mineral. Deducting, therefore, the carbonate of lime and reducing the remaining members to per-centage proportions, they will stand thus:—

	Oxygen.		Ratio.
Silica, . .	52·00	27·01	7
Alumina, . .	25·42	11·88	3
Peroxyd of iron,	1·54	·47	
Magnesia, . .	5·39	2·08	1
Potash, . .	10·38	1·75	
Water, . .	5·27	4·68	1 or 1⅓
	100·00		

The above composition is very well represented by the formula,

$$(\dot{M}g, \dot{K})^3 \dddot{Si} + 3\ddot{\bar{A}}l \dddot{Si}^2 + 3\dot{H}.$$

Boston, April 18, 1850.

Art. XI.—*On the Telluric Bismuth of Virginia;* by Dr. C. T. Jackson.

I discovered this ore in May, 1848, among some specimens of native gold given me by Mr. Knowles Taylor. At that time I had not a sufficient quantity of the mineral to enable me to make a complete analysis of it, but having made a blowpipe assay and satisfied myself that it was an ore of Tellurium, I communicated my results to the American Journal of Science and Arts, and my note was published in vol. vi, No. 17, 1848, p. 188.

My only object then was to announce the discovery of Tellurium, and I intended at the earliest moment in my power to procure a larger supply of the ore and to complete my analysis. Subsequently, Mr. Fisher* of Philadelphia made an analysis of a specimen which he obtained from the mint, and discovered that the metal which I had supposed to be lead in my cupellation process was bismuth. This fact I am enabled to confirm by my own analysis. Mr. Fisher states that selenium takes the place of sulphur. This is not the case in my specimens, all of which yield sulphur when treated by nitric acid or by the blowpipe, and selenium exists only in minute traces.

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* This Journal, [2] vii, 282.

Last spring I made a hasty visit to the gold mines of Spottsylvania County, Va., and obtained at Whitehall a few pieces of the tellurium ore. These specimens were in mica slate in nodules, and were incrusted with yellow oxyd of bismuth. The gold found in these specimens is not chemically united with the tellurium ore, but exists in small scales between the folia in its metallic state and varies in proportions from 2 to 5 per cent. The tellurium ore is found incrusting masses of native gold, and the edges of the laminæ of tellurium ore impress the metallic gold with well marked striæ and indentations indicating that the tellurium ore was deposited first in the cavities or veins, and the gold was then deposited upon it. This is the order of deposition in many specimens I have seen.

The tellurium ore is found both in the quartz beds or veins and in the mica slate, and is always mixed with native gold.

Form, thin scales frequently intersecting each other; no regular crystals observed. Occurs in lamellar masses readily cleavable, the laminæ splitting like sulphuret of molybdena, which it much resembles in appearance. It is flexible and not elastic. Sectile and not brittle. Color and lustre like flexible foliated graphite. Its hardness =1. Lustre splendent metallic. Color of streak like that of lead.

Analysis on one gramme of the picked scales :—

Bismuth, ...	58·80
Tellurium, ...	35·05
Gold, ox. iron and earthy matter, . .	2·70
Sulphur, ...	3·65
	100·20

This gives the formula of Tetradymite, $2\mathrm{Bi\,Te}^3+\mathrm{Bi\,S}^3=$ Bismuth 59·6, sulphur 4·5, tellurium 35·9.

The tellurium after it was reduced by sulphurous acid, was attacked by means of carbonate and nitrate of potash by fusion, and the contents of the crucible being dissolved and acidulated by means of nitric acid and treated with nitrate of baryta, did not give a weighable quantity of seleniate of baryta. The selenium therefore exists only in minute proportions and is a mere *trace*.

In addition to the above, I would observe that the yellow oxyd of bismuth occurring investing the nodules of tellurium ore, is not carbonate of bismuth, for it does not effervesce with acids. Dr. Chilton had observed *carbonate of bismuth* with the gold rock of South Carolina, some time before I found this, and sent me a specimen of it. This ore, (bismutite,) from the gold district of Chesterfield, S. C., has been analyzed by Rammelsberg, (Pogg. Ann., lxxvi, 569, 1849,) who obtained $\dddot{\bar{\mathrm{B}}}\mathrm{i}$ 90·00, $\ddot{\mathrm{C}}$ 6·56, $\dot{\mathrm{H}}$ 3·44, whence he has deduced the formula $3(\dddot{\bar{\mathrm{B}}}\mathrm{i}\,\ddot{\mathrm{C}}+\dot{\mathrm{H}})+\dddot{\bar{\mathrm{B}}}\mathrm{i}\,\dot{\mathrm{H}}$, equivalent to $4\dddot{\bar{\mathrm{B}}}\mathrm{i}$, $3\ddot{\mathrm{C}}$, $4\dot{\mathrm{H}}$.

ART. XII.—*On a supposed New Mineral Species;* by HENRY WURTZ, of New York.

THIS mineral was found near Cambridge, Mass., at "Milk Row Quarry," the well-known locality of prehnite. It occurs as an incrustation upon the surface of the syenitic rock, coating the sides of fissures, and presenting the appearance of brilliant plates overlying one another like the scales of a fish.

Its color is black; lustre, resinous; streak, dark olive green; structure, distinctly fibrous, somewhat like that of tremolite; feel, soapy. Hardness, about 2; slightly translucent in thin laminæ. The fibres are brittle. No cleavage was found. Under the lens it exhibits white crystalline specks, which the analysis proved to be calcareous spar.

It is easily decomposed with effervescence by hydrochloric acid, which is thereby colored deep green, silica being left behind as a white powder. Its fusibility is about that of natrolite, or 2 on Kobell's scale. It fuses to a dull black opaque globule which is slightly magnetic.

Two determinations of the specific gravity, made upon two different specimens, gave the same number, 2·69, which being about the specific gravity of calcareous spar, no correction due to the 12 to 23 per cent. of this mineral which the analyses indicate, need be made.

Qualitative analysis indicated the presence of carbonic acid, water, lime, soda, silica, oxyd of iron and alumina.

For the quantitative analysis, a portion of the mineral was finely elutriated, and then dried at 212° in a steam-bath until it lost no more weight. Attempts to separate the calc spar by means of very dilute acetic acid were unsuccessful. The acid became immediately colored red by dissolving some of the iron.

When the dark-green powder of this mineral is heated to redness in the air, it assumes upon cooling a red color, indicating peroxydation of the iron. The water determinations were therefore made in small bent tubes, which were sealed up immediately after the expulsion of the water, and the mass thus cooled out of contact with the air. The residue, after the expulsion of the HO, had, in this case, a black color.

The carbonic acid was determined by the well known method of the weighed flask and Ca Cl tube.

The other constituents were determined in the usual manner, by dissolving the mineral in HCl, etc. In making the two following analyses, the most extreme precautions were used to ensure accuracy. Every product of the analysis was reanalyzed after being weighed. Thus, the silica, after being weighed, was fused with carbonate of soda and the $\dddot{\text{Al}}$ and $\dddot{\text{Fe}}$ which had been left in it by the HCl separated, weighed, and added to the HCl solution, their weight being deducted from that of the silica. In one case, this weight amounted to half a per cent. of the substance used. Difficulty being found in separating the $\dddot{\text{Al}}$ and $\dddot{\text{Fe}}$, by means of KO, in one experiment the $\dddot{\text{Fe}}$ and $\dddot{\text{Al}}$ were weighed together, and the $\dddot{\text{Al}}$ calculated by deducting the amount of $\dddot{\text{Fe}}$ afterwards found in the mass.

	I.	II.	Mean.	Oxygen.
$\dddot{\text{Si}}$	27·70	27·32	27·51	14·29
$\dddot{\text{Al}}$	10·30	10·17	10·23	4·78
$\dot{\text{Fe}}$	27·99	27·55	27·77	6·17
$\dot{\text{Na}}$	1·23	. .	1·23	·32
$\dot{\text{H}}$	8·69	8·73	8·71	7·74
$\dot{\text{Ca}}$	12·25	12·98	12·61	
$\ddot{\text{C}}$	10·32	10·09	10·29	
			98·35	

The first thing to be observed here is that the quantity of $\ddot{\text{C}}$ found is just sufficient to form $\dot{\text{Ca}}\ddot{\text{C}}$ with the $\dot{\text{Ca}}$ found, 12·61 $\dot{\text{Ca}}$ requiring 9·91 $\ddot{\text{C}}$, so that, in all probability, the lime present is all in the form of calc spar.

So far, I had proceeded upon the hypothesis that this mineral contained no $\dddot{\text{Fe}}$, judging from its deep color and the color of its solution in HCl; knowing also that the best analysts have generally supposed that all the iron contained in minerals which give deep green powders is in the form of Fe O. This error of which so many examples may be found in mineralogical works, has its origin in the great difficulties always met with in the separation of the two oxyds of iron from one another, and also in the small difference between the equivalents of the two oxyds,—9 per cent. of protoxyd making only 10 per cent. of peroxyd.

The suggestion of a scientific friend that the mineral might still contain both oxyds, led to a renewal of my research.

The stock of elutriated material, originally prepared, being exhausted, it was necessary to repeat the analysis from the beginning on another specimen, which was accordingly done, in the same manner as previously, with the exception that the $\dddot{\text{Fe}}$ was determined according to the method of Fuchs, that is, by weighing a piece of bright copper before and after its immersion in the HCl solution of a weighed quantity of the mineral, contained in a stoppered bottle, which was kept, during the operation, in boiling water. The ratio of the loss sustained by the copper to the $\dddot{\mathrm{Fe}}$ present, is that of their equivalents.

	I.	II.	Oxygen.	
$\overline{\mathrm{Si}}$	30·86	30·93	16·05	16·05
$\dddot{\mathrm{Al}}$	3·92	. .	1·83	7·89
$\dddot{\mathrm{Fe}}$	20·25	20·17	6·06	
$\dot{\mathrm{Fe}}$	21·97	. .	4·88	5·30
$\dot{\mathrm{Na}}$	1·62	. .	·42	
$\dot{\mathrm{Ca}}\,\ddot{\mathrm{C}}$	12·77	. .		
$\dot{\mathrm{H}}$	8·94	. .	7·95	7·95
	100·33			

The ratio for the oxygen of the protoxyds, peroxyds, silica and water, 5·30 : 7·89 : 16·05 : 7·95 = 1 : 1·49 : 3·03 : 1·50 or quite closely 1 : 1½ : 3 : 1½. This gives the general formula

$$\dot{\mathrm{R}}^2\,\overline{\mathrm{Si}}+\dddot{\mathrm{R}}\,\overline{\mathrm{Si}}+3\dot{\mathrm{H}}$$

or the special formula,

$$(1.)\qquad (\dot{\mathrm{Fe}}\tfrac{581}{631}+\dot{\mathrm{Na}}\tfrac{50}{631})^2\,\overline{\mathrm{Si}}+(\dddot{\mathrm{Al}}\tfrac{10}{43}+\dddot{\mathrm{Fe}}\tfrac{33}{43})\overline{\mathrm{Si}}+3\dot{\mathrm{H}}.$$

An attempt to bring the first two analyses under this formula gave the following result. If we suppose that a portion of the iron, whose oxygen, when in the form of $\dddot{\mathrm{Fe}}$, is equal to one-half of the oxygen of the $\dddot{\mathrm{Al}}$ present, was actually present in the form of $\dddot{\mathrm{Fe}}$, the following numbers present themselves:—

		Mean.		Oxygen.		
$\overline{\mathrm{Si}}$	. .	27·51	.	14·29	.	14·29
$\dddot{\mathrm{Al}}$	. .	10·23	.	4·78	.	7·17
$\dddot{\mathrm{Fe}}$	. .	7·97	.	2·39		
$\dot{\mathrm{Fe}}$	. .	20·60	.	4·58	.	4·90
$\dot{\mathrm{Na}}$	. .	1·23	.	·32		
$\dot{\mathrm{H}}$	. .	8·71	.	7·74	.	7·74
$\dot{\mathrm{Ca}}\,\ddot{\mathrm{C}}$	. .	22·90				
		99·15				

The ratio 4·90 : 7·17 : 14·29 : 7·74 = 1 : 1·46 : 2·92 : 1·58 or nearly 1 : 1½ : 3 : 1½, as before.

Thus, upon this hypothesis, the general formula $\dot{\mathrm{R}}^2\,\overline{\mathrm{Si}}+\dddot{\mathrm{R}}\,\overline{\mathrm{Si}}+3\dot{\mathrm{H}}$ represents these analyses also very well. The special formula for this variety would be

$$(2.)\qquad (\dot{\mathrm{Fe}}\tfrac{14}{15}+\dot{\mathrm{Na}}\tfrac{1}{15})^2\,\overline{\mathrm{Si}}+(\dddot{\mathrm{Al}}\tfrac{2}{3}+\dddot{\mathrm{Fe}}\tfrac{1}{3})\,\overline{\mathrm{Si}}+3\dot{\mathrm{H}}\ (\text{or } 3\tfrac{1}{4}\dot{\mathrm{H}}).$$

The composition is near that of groppite, for which Rammelsberg writes the formula $\dot{\mathrm{R}}^2\,\overline{\mathrm{Si}}+\dddot{\mathrm{R}}\,\overline{\mathrm{Si}}+2\dot{\mathrm{H}}$. But groppite is a rose-red species, containing little iron and lime and much magnesia with potash, and moreover Svanberg's formula for it is very different. There is sufficient reason therefore, for believing the species here described as distinct, and I therefore propose for it the name *Melanolite.*

As the recent investigations of Mr. J. D. Dana, published in the American Journal of Science for March, 1850, have given increased interest to the subject of atomic volume among minerals, I have here calculated the atomic volume of these varieties.

(1.)			(2.)		
$\dddot{\text{Si}}^2$	=	1154·62	$\dddot{\text{Si}}^2$	=	1154·62
$\dddot{\text{Al}}_{\frac{1}{4}\frac{0}{3}}$	=	149·26	$\dddot{\text{Al}}_{\frac{2}{3}}$	=	427·87
$\dddot{\text{Fe}}_{\frac{3}{4}\frac{3}{3}}$	=	767·45	$\dddot{\text{Fe}}_{\frac{1}{3}}$	=	833·33
$\dot{\text{Fe}}1_{\frac{5}{6}\frac{2}{3}\frac{1}{1}}$	=	828·68	$\dot{\text{Fe}}1_{\frac{6}{7}\frac{5}{5}}$	=	840·00
$\dot{\text{Na}}_{\frac{1}{6}\frac{0}{3}\frac{0}{1}}$	=	61·36	$\dot{\text{Na}}_{\frac{1}{7}\frac{0}{5}}$	=	51·63
$\dot{\text{H}}^3$	=	337·50	$\dot{\text{H}}^{3\frac{1}{4}}$	=	365·62
		3298·87			3173·07

These two numbers, which are the atomic weights of the two varieties, divided by the specific gravity 2·69, give for (1), the atomic volume 1226·35, and for (2), 1180·, the difference between which is about $\frac{1}{36}$th. If we go farther, and divide these numbers by the number of atoms of the elements in each variety, we shall obtain the C atomic volume, as this term is used by Mr. Dana. In one case we get 53·32, and in the other 50·21. If reference is now made to the tables of atomic volumes given by Mr. Dana in the American Journal for March, 1850, p. 242, it will be seen that these numbers are nearly identical with those given by him for three varieties of talc, a mineral which the one now under consideration resembles in many important characters. On the contrary, chlorite, a mineral to which this one is so intimately connected as to have been mistaken for it by an eminent mineralogist, gives altogether a different number. I have calculated the C atomic volume of chlorite from one of Kobell's analyses which gives the formula

$$\dddot{\text{Si}}^2+\dddot{\text{Al}}+\dot{\text{Mg}}^{4\frac{1}{3}}+\dot{\text{Fe}}^{\frac{1}{3}}+\dot{\text{H}}^4$$

and obtained 43·6. The hisingerite from Ridderhyttan also resembles this mineral very closely. Its formula, according to Hisinger and Kobell, is $\dot{\text{Fe}}\,\dddot{\text{Si}}+\dddot{\text{Fe}}\,\dddot{\text{Si}}+6\dot{\text{H}}$; and specific gravity 3·045. Its ordinary atomic volume is 1077·05, and its C atomic volume 39·9, thus approaching that of chlorite, instead of that of this mineral.

Laboratory of the Coll. of Phys., Crosby st., New York, April 1, 1850.

Art. XIII.—*The Erratic Phenomena about Lake Superior;*

by Prof. Agassiz.

[We cannot better notice the very valuable and interesting work of Prof. Agassiz and his associates upon the Lake Superior Region,* than by citing one of its chapters. The following observations on the Erratic Phenomena of the region constitute Chapter X, of the work, pages 395–416.]

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* The title of the volume and its contents are mentioned in our last number, p. 455.

So much has been said and written within the last fifteen years, upon the dispersion of erratic boulders and drift, both in Europe and America, that I should not venture to introduce this subject again, if I were not conscious of having essential additions to present to those interested in the investigation of these subjects.

It will be remarked by all who have followed the discussions respecting the transportation of loose materials over great distances from the spot where they occurred primitively, that the most minute and the most careful investigations have been made by those geologists who have attempted to establish a new theory of their transportation by the agency of ice.

The part of those who claim currents as the cause of this transportation has been more generally negative, inasmuch as, satisfied with their views, they have generally been contented simply to deny the new theory and its consequences, rather than investigate anew the field upon which they had founded their opinions. Without being taxed with partiality, I may, at the outset, insist upon this difference in the part taken by the two contending parties. For since the publication of Sefstroem's paper upon the drift of Sweden, in which very valuable information is given respecting the phenomena observed in that peninsula, and the additional data furnished by de Verneuil and Murchison upon the same country and the plains of Russia, the classical ground for erratic phenomena has been left almost untouched by all except the advocates of the glacial theory. I need only refer to the investigations of M. de Charpentier, Escher, Von Derlinth and Studer, and more particularly to those extensive and most minute researches of Prof. Guyot in Switzerland, without speaking of my own and some contributions from visitors, as the Martins, James Forbes and others, to justify my assertion that no important fact respecting the loose materials spread all over Switzerland has been added by the advocates of currents since the days of Saussure, de Lüc, Escher and Von Buch; whilst Prof. Guyot has most conclusively shown that the different erratic basins in Switzerland are not only distinct from each other, as was already known before, but that in each the loose materials are arranged in well-determined regular order, showing precise relations to the centres of distribution, from which these materials originated; an arrangement which agrees in every particular with the arrangement of loose fragments upon the surface of any glacier, but which no cause acting convulsively could have produced.*

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* A comparison of the maps showing the arrangement of the moraines upon the glacier of the Aar in my *Système Glaciaire*, with the map which Prof. Guyot is about to publish of the distribution of the erratic boulders in Switzerland, will show more fully the identity of the two phenomena.

The results of these investigations are plainly that the boulders found at a distance from the central Alps, originated from their higher summits and valleys, and were carried down at different successive periods in a regular manner, forming uninterrupted walls and ridges, which can be traced from their starting point to their extreme peripheric distribution.

I have myself shown that there are such centres of distribution in Scotland and England and Ireland. And these facts have been since traced in detail in various parts of the British Islands by Dr. Buckland, Sir Ch. Lyell, Mr. Darwin, Mr. McLachlan and Professor James D. Forbes, pointing clearly to the main mountain groups as to so many distinct centres of dispersion of these loose materials.

Similar phenomena have been shown in the Pyrenees, in the Black Forest, and in the Vosges, showing beyond question, that whatever might have been the cause of the dispersion of erratic boulders, there are several separate centres of their distribution to be distinguished in Europe. But there is another question connected with this local distribution of boulders which requires particular investigation, the confusion of which with the former has no doubt greatly contributed to retard our real progress in understanding the general question of the distribution of erratics.

It is well known that Northern Europe is strewed with boulders, extending over European Russia, Poland, Northern Germany, Holland and Belgium. The origin of these boulders is far north in Norway, Sweden, Lapland and Liefland, but they are now diffused over the extensive plains west of the Ural Mountains. Their arrangement, however, is such that they cannot be referred to one single point of origin, but only in a general way to the northern tracts of land which rise above the level of the sea in the Arctic regions. Whether these boulders were transported by the same agency as those arising from distinct centres, on the main continent of Europe, has been the chief point of discussion. For my own part, I have indeed no doubt that the extreme consequences to which we are naturally carried by admitting that ice was also the agent in transporting the northern erratics to their present positions, has been the chief objection to the view that the Alpine boulders have been distributed by glaciers.

It seemed easier to account for the distribution of the northern erratics by currents, and this view appearing satisfactory to those who supported it, they at once went further, and opposed the glacial theory even in those districts where the glaciers seemed to give a more natural and more satisfactory explanation of the phenomena. To embrace the whole question it should be ascertained,

First, Whether the northern erratics were transported at the same time as the local Alpine boulders, and if not, which of the phenomena preceded the other; and again, if the same cause acted in both cases, or if one of the causes can be applied to one series of these phenomena, and the other cause to the other series. An investigation of the erratic phenomena in North America seems to me likely to settle this question, as the northern erratics occur here in an undisturbed continuation over tracts of land far more extensive than those in which they have been observed in Europe. For my own part, I have already traced them from the eastern shores of Nova Scotia through New England and the North Western States of North America and the Canadas as far as the western extremity of Lake Superior, a region embracing about thirty degrees of longitude. Here, as in Northern Europe, the boulders evidently originated farther north than their present location, and have been moved universally in a main direction from north to south.

From data which are, however, rather incomplete, it can be further admitted that similar phenomena occur further west across the whole continent, everywhere presenting the same relations. That is to say, everywhere pointing to the north as to the region of the boulders, which generally disappear about latitude 38°.

Without entering at present into a full discussion of any theoretical views of the subject, it is plain that any theory, to be satisfactory, should embrace both the extensive northern phenomena in Europe and North America, and settle the relation of these phenomena to the well-authenticated local phenomena of Central Europe.

Whether America itself has its special local circumscribed centres of distribution or not, remains to be seen. It seems, however, from a few facts observed in the White Mountains, that this chain, as well as the mountains of northeastern New York, has not been exclusively—and for the whole duration of the transportation of these materials—under the influence of the cause which has distributed the erratics through such wide space over the continent of North America. But whether this be the case or not, (and I trust local investigations will soon settle the question,) I maintain that the cause which has transported these boulders in the American continent must have acted simultaneously over the whole ground which these boulders cover, as they present throughout the continent an uninterrupted sheet of loose materials, of the same general nature, connected in the same general manner, and evidently dispersed at the same time.

Moreover, there is no ground, at present, to doubt the simultaneous dispersion of the erratics over Northern Europe and Northern America. So that the cause which transported them, whatever it may be, must have acted simultaneously over the whole tract of land west of the Ural Mountains, and east of the Rocky Mountains, without assuming any thing respecting Northern Asia, which has not yet been studied in this respect; that is to say, at the same time, over a space embracing two hundred degrees of longitude.

Again, the action of this cause must have been such, and I insist strongly upon this as a fundamental point, the momentum with which it acted must have been such, that after being set in motion in the north, with a power sufficient to carry the large boulders which are found everywhere over this vast extent of land, it vanished or was stopped after reaching the thirty-fifth degree of northern latitude.

Now it is my deliberate opinion that natural philosophy and mathematics may settle the question, whether a body of water of sufficient extent to produce such phenomena can be set in motion with sufficient velocity to move all these boulders, and nevertheless stop before having swept over the whole surface of the globe. Hydrographers are familiar with the action of currents, with their speed, and the power with which they can act. They know also how they are distributed over our globe. And, if we institute a comparison, it will be seen that there is nowhere a current running from the poles towards the lower latitudes, either in the northern or southern hemisphere, covering a space equal to one-tenth of the currents which should have existed to carry the erratics into their present position. The widest current is west of the Pacific, which runs parallel to the equator, across the whole extent of that sea from east to west, and the greatest width of which is scarcely fifty degrees. This current, as a matter of course, establishes a regular rotation between the waters flowing from the polar regions towards lower latitudes.

The Gulf Stream on the contrary runs from west to east, and dies out towards Europe and Africa, and is compensated by the currents from Baffin's Bay and Spitzbergen emptying into the Atlantic, while the current of the Pacific, moving towards Asia and carrying floods of water in that direction, is maintained chiefly by antarctic currents, and those which follow the western shore of America from Behring's Straits. Wherever they are limited by continents, we see that the waters of these currents, even when they extend over hundreds of degrees of latitude, as the Gulf Stream does in its whole course, are deflected where they cannot follow a straight course.

Now without appealing with more detail to the mechanical conditions involved in this inquiry, I ask every unprejudiced mind acquainted with the distribution of the northern boulders, whether there was any geographical limitation to the supposed northern current to cause it to leave the northern erratics of Europe in such regular order, with a constant bearing from north to south, and to form, on its southern termination, a wide, regular zone from Asia to the western shores of Europe, north of the fiftieth degree of latitude, before it had reached the great barrier of the Alps? I ask whether there was such a barrier in the unlimited plains which stretch from the Arctic seas uninterrupted over the whole northern continent of America as far down as the Gulf of Mexico?

I ask, again, why the erratics are circumscribed within the northern limits of the temperate zone, if their transportation is owing to the action of water currents? Does not, on the contrary, this most surprising limit within the arctic and northern temperate zones, and in the same manner within the antarctic and southern temperate zones, distinctly show that the cause of transportation is connected with the temperature or climate of the countries over which the phenomena were produced. If it were otherwise, why are there no systems of erratics with an east and west bearing, or in the main direction of the most extensive currents flowing at present over the surface of our globe?

It is a matter of fact, of undeniable fact, for which the theory has to account, that in the two hemispheres the erratics have direct reference to the polar regions, and are circumscribed within the arctics and the colder part of the temperate zone. This fact is as plain as the other fact, that the local distribution of boulders has reference to high mountain ranges, to groups of land raised above the level of the sea into heights, the temperature of which is lower than the surrounding plains. And what is still more astonishing, the extent of the local boulders, from their centre of distribution reaches levels, the mean annual temperature of which corresponds in a surprising manner with the mean annual temperature of the southern limit of the northern erratics.

We have, therefore, in this agreement a strong evidence in favor of the view that both the phenomena of local mountain erratics in Europe and of northern erratics in Europe and America have probably been produced by the same cause.

The chief difficulty is in conceiving the possibility of the formation of a sheet of ice sufficiently large to carry the northern erratics into their present limits of distribution; but this difficulty is greatly removed when we can trace, as in the Alps, the progress of the boulders under the same aspect from the glaciers now existing, down into regions where they no longer exist, but where the boulders and other phenomena attending their transportation show distinctly that they once existed.

Without extending further this argumentation, I would call the attention of the unprejudiced observer to the fact, that those who advocate currents as the cause of the transportation of erratics, have, up to this day, failed to show, in a single instance, that currents can produce all the different phenomena connected with the transportation of the boulders which are observed everywhere in the Alps, and which are still daily produced there by the small glaciers yet in existence. Never do we find that water leaves the boulders which it carries along in regular walls of mixed materials; nor do currents any where produce upon the hard rocks *in situ* the peculiar grooves and scratches which we see everywhere under the glacier and within the limits of their ordinary oscillations.

Water may polish the rocks, but it nowhere leaves straight scratches upon their surface; it may furrow them, but these furrows are sinuous, acting more powerfully upon the soft parts of the rocks or fissures already existing; whilst glaciers smooth and level uniformly, the hardest parts equally with the softest, and, like a hard file, rub to uniform continuous surfaces the rocks upon which they move.

But now let us return to our special subject, the erratics of North America.

The phenomena of drift are more complicated about Lake Superior than I have seen them any where else; for, besides the general phenomena which occur everywhere, there are some peculiarities noticed which are to be ascribed to the lake as such, and which we do not find in places where no large sheet of water has been brought into contact with the erratic phenomena. In the first place, we notice about Lake Superior an extensive tract of polished, grooved and scratched rocks, which present here the same uniform character which they have everywhere. As there is so little disposition, among so many otherwise intelligent geologists, to perceive the facts as they are, whenever they bear upon the question of drift, I cannot but repeat, what I have already mentioned more than once, but what I have observed again here over a tract of some fifteen hundred miles, that the rocks are everywhere smoothed, rounded, grooved and furrowed in a uniform direction. The heterogeneous materials of which the rocks consist are cut to one continuous uniform level, showing plainly that no difference in the polish and abrasion can be attributed to the greater or less resistance on the part of the rocks, but that a continuous rasp cut down every thing, adapting itself, however, to the general undulations of the country, but nevertheless showing, in this close adaptation, a most remarkable continuity in its action.

That the power which produced these phenomena moved in the main from north to south, is distinctly shown by the form of the hills, which present abrupt slopes, rough and sharp corners towards the south, while they are all smoothed off towards the north.

Indeed, here, as in Norway and Sweden, there is on all the hills a lee-side and a strike-side. As has been observed in Norway and Sweden, the polishing is very perfect in many places, sometimes strictly as brilliant as a polished metallic surface, and everywhere these surfaces are more or less scratched and furrowed, and both scratches and furrows are rectilinear, crossing each other under various angles: however, never varying many points of the compass on the same spot, but in general showing that where there are deviations from the most prominent direction, they are influenced by the undulations of the soil. It has been said, that the main direction of these striæ was from northwest to southeast, but I have found it as often strictly from north to south, or even from northeast to southwest; and if we are to express a general result, we should say that the direction, assigned by all our observations to the various scratches, tends to show that they have been formed under the influence of a movement from north to south, varying more or less to the east and west, according to local influences in the undulations of the soil. It is, indeed, a very important fact, that scratches which seem to have been produced at no great intervals from each other, are not absolutely parallel, but may diverge for ten, fifteen, or more degrees.

There is one feature in these phenomena, however, in which we never observe any variation. The continuity of these lines is absolutely the same everywhere. They are rectilinear and continuous, and cannot be better compared than with the effects of stones or other hard materials dragged in the same direction upon flat or rolling surfaces; they form simple scratches extending for yards in straight lines, or breaking off for a short space to continue again in a straight line in the same direction, just as if interrupted by a jerk. There are also deeper scratches of the same kind, presenting the same phenomena, only, perhaps, traceable for a greater distance than the finer ones. These scratches, instead of appearing like the tracing of diamonds upon glass, as the former do, would rather assume the appearance of a deeper groove, made by the point of a graver, or perhaps still more closely resemble the scratches which a cart-wheel would produce upon polished marble, if the wheel were chained, and coarse sand spread over the floor, the wheel continuing to move onward but without revolving. The appearance of the surface, crushed by the moving mass, is especially distinct in limestone rocks, where grooves are seldom nicely cut, but present the appearance of a violent pressure combined with the grooving power, thus giving to the groove a character which is quite peculiar, and which at once strikes an observer who has been familiar with its characteristic aspect. Now, I do not know upon what the assertions of some geologists rest, that gravel moved by water under strong heavy currents will produce similar effects. Wherever I have gone since studying these phenomena, I have looked for such cases, and have never yet found modern gravel currents produce any thing more than a smooth surface with undulating furrows following the cracks in the rocks, or hollowing their softer parts; but continuous straight lines, especially such crushed lines and straight furrows, I have never seen.

When we know how extensive the action of water carrying mud and gravel is on every shore and in every water current,—when we can trace this action almost everywhere, and no where find it similar to the phenomena just described, I cannot imagine upon what ground these phenomena are still attributed to the agency of currents. This is the less rational as we have at present, in all high mountain chains of the temperate zone, other agents, the glaciers, producing these very same phenomena, with precisely the same characters, to which, therefore, a sound philosophy should ascribe, at least conditionally, the northern and Alpine polished surfaces, and scratched and grooved rocks, or at least acknowledge that the effect produced by the action of glaciers more nearly resembles these erratic phenomena than does that which results from the action of currents. But such is the prejudice of many geologists, that those keen faculties of distinction and generalization, that power of superior perception and discrimination which have led them to make such brilliant discoveries in geology in general, seem to abandon them at once as soon as they look at the erratics. The objection made by a venerable geologist, that the cold required to form and preserve such glaciers, for any length of time, would freeze him to death, is as childish as the apprehension that the heavy ocean currents, the action of which he sees everywhere, might have swept him away.*

Now that these phenomena have been observed extensively, we may derive also some instruction from the limits of their geographical extent. Let us see, therefore, where these polished, scratched and furrowed rocks have been observed.

In the first place they occur everywhere in the north within certain limits of the arctics, and through the colder parts of the temperate zone. They occur also in the southern hemisphere, within parallel limits, but in the plains of the tropics, and even in the warmer parts of the temperate zone we find no trace of these phenomena, and nevertheless the action of currents could not be less there, and could not at any time have been less than in the colder climates. It is true, similar phenomena occur in Central Europe and have been noticed in Central Asia, and even in the Andes of South America, but these always in higher regions, at definite levels above the surface of the sea, everywhere indicating a connection between their extent and the colder temperature of the places over which they are traced.

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* Berlin Academy, 1846.

More recently, a step towards the views I entertain of this subject, has been made by those geologists who would ascribe them to the agency of icebergs. Here, as in my glacial theory, ice is made the agent; floating ice is supposed to have ground and polished the surfaces of rocks, while I consider them to have been acted upon by terrestrial glaciers. To settle this difference we have a test which is as irresistible as the other arguments already introduced.

Let us investigate the mode of action, the mode of transportation of icebergs, and let us examine whether this cause is adequate to produce phenomena for which it is made to account. As mentioned above, the polished surfaces are continuous over hills, and in depressions of the soil, and the scratches which run over such undulating surfaces are nevertheless continuous in straight lines. If we imagine icebergs moving upon shoals, no doubt they would scratch and polish the rocks in a way similar to moving glaciers. But upon such localities they would sooner or later be stranded, and if they remained loose enough to move, they would, in their gyratory movements, produce curved lines, and mark the spots where they had been stranded with particular indications of their prolonged action. But nowhere upon arctic ground do we find such indications. Everywhere the polished and scratched surfaces are continuous in straight juxtaposition.

Phenomena analogous to those produced by icebergs would only be seen along the sea-shores; and if the theory of drifted icebergs were correct, we should have, all over those continents where erratic phenomena occur, indications of retreating shores as far as the erratic phenomena are found. But there is no such thing to be observed over the whole extent of the North American continent, nor over Northern Europe and Asia, as far as the northern erratics extend. From the arctics to the southernmost limit of the erratic distribution, we find nowhere the indications of the action of the sea as directly connected with the production of the erratic phenomena. And wherever the marine deposits rest upon the polished surfaces of ground and scratched rocks, they can be shown to be deposits formed since the grooving and polishing of the rocks, in consequence of the subsidence of those tracts of land upon which such deposits occur.

Again, if we take for a moment into consideration the immense extent of land covered by erratic phenomena, and view them as produced by drifted icebergs, we must acknowledge that the icebergs of the *present period* at least, are insufficient to account for them, as they are limited to a narrower zone. And to bring icebergs in any way within the extent which would answer for the extent of the distribution of erratics, we must assume that the northern ice fields, from which these icebergs could be detached and float southwards, were much larger at the time they produced such extensive phenomena than they are now. That is to say, we must assume an ice period; and if we look into the circumstances we shall find that this ice period, to answer to the phenomena, should be nothing less than an extensive cap of ice upon both poles. This is the very theory which I advocate; and unless the advocates of an iceberg theory go to that length in their premises, I venture to say, without fear of contradiction, that they will find the source of their icebergs fall short of the requisite conditions which they must assume, upon due consideration, to account for the whole phenomena as they have really been observed.

But without discussing any farther the theoretical views of the question, let me describe more minutely the facts as observed on the northern shores of Lake Superior. The polished surfaces, as such, are even, undulating, and terminate always above the rough lee-side turned to the south, unless upon gentle declivities, where the polished surfaces extend in unbroken continuity upon the southern surfaces of the hills, as well as upon their northern slopes. On their eastern and western flanks, shallow valleys running east and west are as uniformly polished as those which run north and south; and this fact is more and more evident, wherever scratches and furrows are also well preserved and distinctly seen, and by their bearings we can ascertain most minutely, the direction of the onward movement which produced the whole phenomena. Nothing is more striking in this respect than the valleys or depressions of the soil running east and west, where we see the scratches crossing such undulations at right angles, descending along the southern gentle slope of a hill, traversing the flat bottom below, and rising again up the next hill south, in unbroken continuity. Examples of the kind can be seen everywhere in those narrow inlets, with shallow waters intersecting the innumerable highlands along the northern shores of Lake Superior, where the scratches and furrows can be traced under water from one shore to the other, and where they at times ascend steep hills, which they cross at right angles along their northern slope, even when the southern slope, not steeper in itself, faces the south with rough escarpments.

The scratches and furrows, though generally running north and south, and deviating slightly to the east and west, present in various places remarkable anomalies, even in their general course along the eastern shore of the lake. Between Michipicotin and Sault St. Marie we more frequently see a deflection to the west than a due north and south course, which is rather normal along the northern shore proper, between Michipicotin and other islands, and from the Pic to Fort William; the deep depression of the lake being no doubt the cause of such a deviation, as large masses of ice could accumulate in this extensive hollow cavity before spreading again more uniformly beyond its limits. To the oscillations of the whole mass in its southerly movement, according to the inequalities of the surfaces, we must ascribe the crossing of the straight lines at acute angles, as we observe also at the present day under the glaciers, as they swell and subside, and hence meet with higher and lower obstacles in their irregular course between the Alpine valleys.

In deep, narrow chasms, however, we find now and then greater deviations from the normal direction of the striæ, where considerable masses of ice could accumulate, and move between steep walls under a lateral pressure of the masses moving onwards from the north. Such a chasm is seen between Spar Island and the main land opposite Prince's Location, south of Fort William, where the furrows and scratches run nearly east and west. But here also, there is no tumultuous disturbance in the continuation of the phenomena, such as would occur if icebergs were floated and stranded against the southern barrier. The same continuity of even, polished surfaces, with their scratches and furrows, prevails here as elsewhere. The angles which these scratches form with each other are very acute, generally not exceeding 10°; but at times they diverge more, forming angles of 15°, 20° and 25°. In a few instances, I have even found localities where they crossed each other at angles of no less than 30°; but these are rare exceptions. It may sometimes be noticed that the lines running in one direction form a system by themselves, varying very little from strict parallelism with each other, but crossing another system, more or less strongly marked, of other lines equally parallel with each other. At other times, a system of lines, strongly marked and diverging very slightly, seem to pass over another system, in which the lines form various angles with each other. Again, there are places,—and this is the most common case,—where the lines diverge slightly, following, however, generally one main direction, which is crossed by fewer lines, forming more open angles. These differences, no doubt, indicate various oscillations in the movement of the mass which produced the lines, and show probably its successive action, with more or less intensity, upon the same point at successive periods, in accordance with the direction of the moving force at each interval. The same variations within precisely the same limits may be noticed in our day on the margin of the glaciers produced by the increase or diminution of the bulk of their mass, and the changes in the rate of their movement.

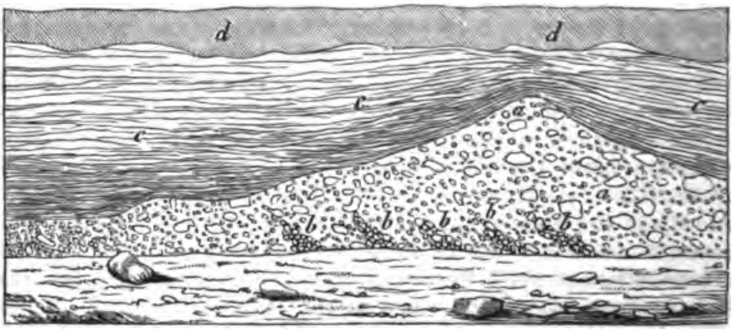
The loose materials which produced, in their onward movement under the pressure force, such polishing and grooving, consisted of various sized boulders, pebbles and gravels, down to the most minute sand and loamy powder. Accumulations of such materials are found everywhere upon these smooth surfaces, and in their arrangement they present everywhere the most striking contrast when compared with deposits accumulated under the agency of water. Indeed, we nowhere find this glacial drift regularly stratified, being everywhere irregular accumulations of loose materials, scattered at random without selection, the coarsest and most minute particles being piled irregularly in larger or smaller heaps, the greatest boulders standing sometimes uppermost, or in the centre, or in any position among smaller pebbles and impalpable powder.

And these materials themselves are scratched, polished and furrowed, and the scratches and furrows are rectilinear as upon the rocks *in situ* underneath, not bruised simply, as the loose materials carried onward by currents or driven against the shores by the tides, but regularly scratched, as fragments of hard materials would be if they had been fastened during their friction against each other, just as we observe them upon the lower surface of glaciers where all the loose materials set in ice, as stones in their setting, are pressed and rubbed against underlying rocks. But the setting here being simply ice, these loose materials, fast at one time and movable another, and fixed and loosened again, have rubbed against the rock below in all possible positions; and hence not only their rounded form, but also their rectilinear grooving. How such grooves could be produced under the action of currents, I leave to the advocates of such a theory to show, as soon as they shall be prepared for it.

I should not omit here to mention a fact which, in my opinion, has a great theoretical importance, namely, that in the northern erratics, even the largest boulders, as far as I know, are rounded, and scratched and polished, at least, all those which are found beyond the immediate vicinity of the higher mountain ranges; showing that the accumulations of ice which moved the northern erratics covered the whole country; and this view is sustained by another set of facts equally important, namely, that the highest ridges, the highest rugged mountains, at least, in this continent and north of the Alps in Europe, are as completely polished and smoothed as the lower lands, and only a very few peaks seem to have risen above the sheet of ice; whilst, in the Alps, the summits of the mountains stand generally above these accumulations of ice, and have supplied the surface of the glaciers with large numbers of angular boulders, which have been carried upon the back of glaciers to the lower valleys and adjacent plains without losing their angular forms.

With respect to the irregular accumulation of drift-materials in the north, I may add that there is not only no indication of stratification among them, such unquestionably as water would have left, but that the very nature of these materials shows plainly that they are of terrestrial origin; for the mud which sticks between them adheres to all the little roughnesses of the pebbles, fills them out, and has the peculiar adhesive character of the mud ground under the glaciers, and differing entirely in that respect from the gravels and pebbles and sands washed by water currents, which leave each pebble clean, and never form adhering masses, unless penetrated by an infiltration of limestone.

Another important fact respecting this glacial drift consists in the universal absence of marine as well as freshwater fossils in its interior, a fact which strengthens the view that they have been accumulated by the agency of strictly terrestrial glaciers; such is, at least, the case everywhere far from the sea-shore. But we may conclude that these ancient glaciers reached, upon various points, the sea-shore at the time of their greatest extension, just as they do at present in Spitzbergen and other arctic shores; and that therefore, in such proximity, phenomena of contact should be observed, indicating the onward movement of glacial material into the ocean, such as the accumulation within these materials of marine fossil remains, and also the influence of the tidal movements upon them. And now such is really the case. Nearer the sea-shores we observe distinctly, in some accumulations of the drift, faint indications of the action of the tide reaching the lower surface of glaciers, and the remodeling, to some extent, of the materials which there poured into the sea. A beautiful example of the kind may be observed near Cambridge, along Charles River, not far from Mount Auburn, where the unstratified glacial drift (*a*) presents in its upper masses strictly the characters of true terrestrial glacial accumulation, but shows underneath faint indications (*b*) of the action of tides. Above, regular tidal strata (*c*) are observed, formed probably after the masses below had subsided. The surface of this accumulation is covered with soil (*d*).



The period at which these phenomena took place cannot be fully determined, nor is it easy to ascertain whether all glacial drift is contemporaneous. It would seem, however, as if the extensive accumulation of drift all around the northern pole in Eu-

-rope, Asia and America was of the same age as the erratics of the Alps. The climatic circumstances capable of accumulating such large masses of ice around the north pole, having, no doubt, extended their influence over the temperate zone, and probably produced, in high mountain chains, as the Alps, the Pyrenees, the Black Forest, and the Vosges, such accumulations of snow and ice, as may have produced the erratic phenomena of those districts. But extensive changes must have taken place in the appearance of the continents over which we trace erratic phenomena, since we observe in the Old World, as well as in North America, extensive stratified deposits containing fossils which rest upon the erratics; and as we have all possible good reasons and satisfactory evidence for admitting that the erratics were transported by the agency of terrestrial glaciers, and that therefore the tracts of land over which they occur, stood at that time above the level of the sea, we are led to the conclusion that these continents have subsided since that period below the level of the sea, and that over their inundated portions animal life has spread, remains of organized beings have been accumulated, which are now found in a fossil state in the deposits formed under those sheets of water.

Such deposits occur at various levels in different parts of North America. They have been noticed about Montreal, on the shores of Lake Champlain, in Maine and also in Sweden and Russia; and, what is most important, they are not everywhere at the same absolute level above the surface of the ocean, showing that both the subsidence, and the subsequent upheaval which has again brought them above the level of the sea, have been unequal; and that we should therefore be very cautious in our inferences respecting both the continental circumstances under which the ancient glaciers were formed, and also the extent of the sea afterward, as compared with its present limits.

The contrast between the unstratified drift and the subsequently stratified deposits is so great, that they rest everywhere unconformably upon each other, showing distinctly the difference of the agency under which they were accumulated. This unconformable superposition of marine drift upon glacial drift is also beautifully shown at the above mentioned locality near Cambridge. (See Diagram.) In this case the action of tides in the accumulation of the stratified materials is plainly seen.

The various heights at which these stratified deposits occur, above the level of the sea, show plainly, that since their accumulation, the main land has been lifted above the ocean at different rates in different parts of the country; and it would be a most important investigation to have their absolute level, in order more fully to ascertain the last changes which our continents have undergone.

From the above mentioned facts, it must be at once obvious that the various kinds of loose materials, all over the northern hemisphere, have been accumulated, not only under different circumstances, but during long-continued subsequent distinct periods, and that great changes have taken place since their deposition, before the present state of things was fully established.

To the first period,—the ice period, as I have called it,—belong all the phenomena connected with the transportation of erratic boulders, the polishing, scratching and furrowing of the rocks and the accumulation of unstratified, scratched, and loamy drift. During that period, the main land seems to have been, to some extent at least, higher above the level of the sea than now; as we observe, on the shores of Great Britain, Norway and Sweden, as well as the eastern shores of North America, the polished surfaces dipping under the level of the ocean, which encroaches everywhere upon the erratics proper, effaces the polished surfaces and remodels the glacial drift. During these periods, large terrestrial animals lived upon both continents, the fossil remains of which are found in the drift of Siberia, as well as of this continent. A fossil elephant recently discovered in Vermont* adds to the resemblance, already pointed out, between the northern drift of Europe and that of North America; for fossils of that genus are now known to occur upon the northernmost point of the western extremity of North America, in New England, in Northern Europe, as well as all over Siberia.

To the second period we would refer the stratified deposits resting upon drift, which indicate that during their deposition the northern continent had again extensively subsided under the surface of the ocean.

During this period, animals, identical with those which occur in the northern seas, spread widely over parts of the globe which are now again above the level of the ocean. But, as this last elevation seems to have been gradual, and is even still going on in our day, there is no possibility of tracing more precisely, at least for the present, the limit between that epoch and the present state of things. Their continuity seems almost demonstrated by the identity of fossil shells found in these stratified deposits, with those now living along the present shores of the same continent, and by the fact that changes in the relative level between sea and main land are still going on in our day.

Indications of such relative changes between the level of the waters and the land are also observed about Lake Superior. And here they assume a very peculiar character, as the level of the lake itself, in its relation to its shores, is extensively changed.

All around Lake Superior we observe terraces at different levels; and these terraces vary in height, from a few feet above the present level of the lake, to several hundred feet above its surface, presenting everywhere undoubted evidence, that they were formed by the waters of the lake itself.

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* See this Journal, vol. ix, p. 256.

As everywhere the lake shores are strewed with sand and pebbles stranded within certain limits by the waves, the lowest accumulations of loose materials remain within the action of heavy storms, and within such limit they are entirely deprived of vegetation.

Next, another set of beaches is observed, consisting generally of coarser materials, forming shelves above the reach of even the severest storms, as shown by the scanty cryptogamus vegetation, and a few small herbaceous plants which have grown upon them.

Next, other beaches, retreating more and more from the shores, are observed, upon which an older vegetation is traced, consisting of shrubs, small trees, and a larger number of different plants, among which extensive carpets of wonderful lichens sometimes spread over large surfaces of greater extent. And the gentle slope of some of the terraces shows that the lake must have stood at this level for a longer time, as higher banks rise precipitously above them, consisting also of loose materials, which must have been worn out and washed away, for a considerable time, by the action of the waves from the lake. In such a manner, terrace above terrace may be observed, in retreating sheltered bays or along protected shores, over extensive tracts; sometimes two or three in close proximity, perhaps within twenty to fifty feet of each other; and again, extensive flat shores, spreading above to another abrupt bank, making the former shore, above which other and other terraces are seen; six, ten, even fifteen such terraces may be distinguished on one spot, forming, as it were, the steps of a gigantic amphitheatre. The most remarkable of all the amphitheatres has been sketched by Mr. Cabot, and forms the frontispiece to this volume. Its height has been determined by Mr. Logan, in his Geographical Report of Canada, page 10, where it is minutely described. I therefore refer to this account for further details. I would only mention here, that the first shelf, within the reach of the lake, consists of minute sand, and forms a narrow strip of sterile ground along the water-edge; next, we have a slope of about 10°, followed by a flat terrace, extending for nearly fifty paces to a second very steep slope, about 26° and 30° inclination; then a sloping terrace with an inclination of near 16°, stretching for eighty to a hundred paces, above which rises another steep slope of 20°, beyond which an extensive flat, slightly sloping, extends for several hundred paces, crowned by some irregular ridges at its summit, and along the rocky ledges which form the bay at the bottom of which this high gravel bank rises.

In connection with these lake terraces, we must consider also the river terraces which present similar phenomena along their banks all around the lake, with the difference that they slope gradually along the water courses, otherwise resembling in their composition the lake terraces, which are altogether composed of remodeled glacial drift, which, from the influence of the water and their having been rolled on the shores, have lost, more or less, their scratches and polished appearance, and have assumed the dead smoothness of water pebbles. Such terraces occur frequently between the islands, or cover low necks connecting promontories with the main land, thus showing, on a small scale, how by the accumulation of loose materials, isolated islands may be combined to form larger ones, and how, in the course of time, by the same process, islands may be connected with the main land.

The lake shores present another series of interesting phenomena, especially near the mouth of larger rivers emptying into the lake over flats, where parallel walls of loose materials, driven by the action of the lake against the mouth of the river, have successively stopped its course and caused it to wind its way between the repeated accumulations of such obstacles.

The lower course of Michipicotin River is for several miles dammed up in that way by concentric walls, across which the river has cut its bed, and winding between them, has repeatedly changed its direction, breaking through the successive walls in different places. The largest and lowest of these walls, a kind of river terrace near the margin of the lake, shuts at present the factory from the immediate lake shore, and the river, which has cut its way between the rocks to the right and the walls, has left a bold bank in this dam on its left shore.

An important question now arises, after considering these facts, how these successive changes in the relative level of the lake and its shores have been introduced. Has the water been gradually subsiding, or has the shore been repeatedly lifted up? Merely from the general inferences of the more extensive phenomena described above, respecting the relative changes between land and sea, I should be inclined to admit that the land has risen, rather than to suppose that the waters have gradually flowed out.

But there are about the lake itself sufficient proofs, which leave in my mind not the slightest doubt that it is the land which has changed its level, and not the lake which has subsided.

In the first place, to suppose that the lake had once stood as high as the highest terraces, it would be necessary to admit that its banks were, all round its shores, sufficiently high to keep the water at that highest level, or, at least, that there were, at the lower outlets, bars to that height, which have been gradually removed since. But neither is the main land sufficiently high, at the western extremity and along the southern shores, to admit of such a supposition, nor is there about the outlet of the lake, between Gros Cap and Cap Iroquois, an indication of a barrier which has been gradually removed. There, as everywhere along the lake shores, the loose movable materials consist of the same drift, the accumulation of which, at various levels, we are aiming to account for. If, therefore, we consider this same drift as the barrier under whose protection the lake modeled other parts of its mass, we should be compelled to admit another cause to remove the barrier, a supposition for which there is not the slightest indication in the geological structure of the country. But if, on the contrary, we suppose the lake to have removed the barrier, there is no cause left for its accumulation, and the changes in the comparative level of the main land and the terraces remain equally unaccounted for.

Indeed, the terraces are so unequal in their absolute level when compared to each other, that a gradual subsidence of the lake removing a barrier of loose materials at its outlet could never explain their irregularity. But if we suppose that the innumerable dykes which cross, in all directions, the rocks which form the shores of the lake, have at various intervals lifted up these shores, we have at the same time a cause for the change of the relative level between the terraces and the lake, and also for the change of its absolute level, as it removed larger and larger portions of materials accumulated at its eastern extremity.

That these dikes have produced such changes will not be doubted by any one who may study the phenomena described in the following chapter respecting the origin of the present outlines of the lakes, as produced by the intersection of all the dikes traversing the metamorphic and plutonic rocks of the northern shores.

We should therefore conclude that, as there has been a general gradual change between the relative level of the main land and sea, so there has also been a gradual local change in the relative level of the lake and its shores; and hence the local phenomena would only corroborate the induction derived from more general geological facts.

Art. XIV.—*Crystallized Gold from California;* by Francis Alger, Boston.*

I have lately had an opportunity of examining some parcels of California gold, which have afforded specimens worthy of especial notice. Those which I purpose to describe in this paper, I obtained from the collections brought home by Mr. George E. Tyler, of this city, and Mr. H. B. Platt, of New York. They consist of well characterized octahedral crystals, simple and modified, the surfaces of which have been but slightly disfigured by attrition, or the effects of transported action usually observed in other specimens. I cannot say that I have ever before seen what was unquestionably a genuine crystal from this new land of gold; an irregular crystalline plane could only occasionally be traced out in former specimens; but here we have examples of crystallization, as perfect among the small ones especially, as are to be seen in magnetic iron ore or in spinelle. The most striking examples on a large scale, are three octahedrons of the dimensions of the accompanying figures. They are isolated crystals, and the smallest one, which is the most perfect, is so entirely free from any adhering portion of the matrix to which it must have been attached, as to lead me to believe that this matrix was a much softer material than the quartz in connection with which the gold is usually found. Although its exact locality is not known, it is probable, as indicated by its slightly worn appearance, that it has been but recently dislodged from its original resting place. This crystal presents four pretty regular faces, and has three of its solid angles perfectly formed to a point. It exhibits no modifications; but two of its faces are depressed—one of them by a very deep cavity which extends not quite to the edges of the plane, but so near to them as to leave a narrow ridge, or border, all around the cavity and parallel with the edges, thus giving the same triangular outline to each. It appears as if the crystal had been in a liquid state, and that soon after the outside had congealed, the inner portion, or a part of it, had run out, leaving the surrounding consolidated edge just referred to. I have seen something similar to this formed among artificial crystals, as for instance, metallic lead (which takes the form of an octahedron) and lead ore partially desulphurized, when the metal was allowed to flow off slowly, just as the outer crust had formed over the surface of the crystals.

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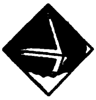
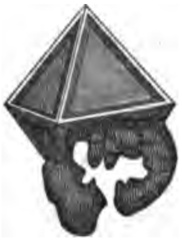
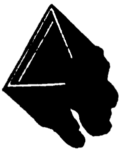
* Read, in part, before the Boston Society of Natural History, April, 1850.







The large crystal presents only one half of the octahedron, its base blending with the massive gold, or only indicating the incipient planes of the lower pyramid. Three of its planes are perfectly smooth surfaces, excepting along their edges, which are prominently marked by the same projecting border or ridge already described on the smaller crystal. This border may have been produced in the same manner by the shrinking away of the metal, or it may be the result of that kind of crystallization which is dependent on a greater intensity of molecular attraction in one direction, or axis, than another. It would seem in this case, as if the molecules arrived at the points of contact along the edges of the crystal, faster than they could be appropriated, and thus they have accumulated in these little ridges. This peculiarity is not confined to the large crystals, for it is observed even among the smallest; but it is confined to the unmodified octahedrons. In a few crystals, there is a double series of these ridges, the inner one representing, apparently, the commencement of another crystalline face within the cavity of the larger one. This is beautifully shown in the third figure on the last page, also answering to the natural size of the crystal.*

The great size of these crystals, and the fact that some of the cavities contained portions of oxyd of iron probably produced by the decomposition of pyrites, have led some to regard them as pseudomorphs of sulphuret of iron. I am not disposed to ascribe any such forced and unnatural origin to these beautiful productions. I believe them to have been formed under the ordinary circumstances of crystallization, either in an open space, or while surrounded by a matrix so soft and accommodating, as to allow them full freedom to take the form it was intended they should take. Were the crystals cubes, there might be some reason for regarding them in the light of pseudomorphs of iron pyrites, because this is the most common form of pyrites, and, moreover, all the pyrites that I have seen from California, has been in that form. But, we may well ask, who has ever seen even a cubic pseudomorph of gold? Crystals of gold are rare, cubes particularly so, and yet this form, on account of its simplicity, is made the primary form; whereas it would seem as reasonable in cases of the regular system, to select that form as the primary which is most commonly and perfectly presented by the mineral, provided there is no cleavage to guide us in the determination; and there does not appear to be any, well made out, among most of the native metals. By assuming those which most commonly occur in nature, we seem to recognize a sort of inherent disposition, a preference, as it were, which is shown by the mineral itself; and we avoid what seems to be a palpable inconsistency, viz., the establishing of a cube as the primary form of minerals which have never been known to occur under such form, and which even present a distinct octahedral cleavage. This is the case with two at least. If we take the simplest form, the cube should be made the primary of native iron, copper, lead, silver, and mercury; and so of some others, which occur in octahedrons and are not determined by any certain cleavage. In the case of copper, some authors have made the cube its primary.[*] Haüy (Traité, 1808) even expressed his doubts as to the existence of cubic gold, while he cites examples of the octahedron; and Beudant, (Min., 1832,) says they are very rare.[†] Mohs implies the contrary, for he says (Min. Ed. by Haidinger) they are often hollow, while the octahedrons are smooth. Cleaveland describes the crystals in general as small and imperfect, and Nicol, in his late work, in the like manner, observes, "they are small and very small." I hope we may yet say of our California gold crystals, they are large and very large, as much for the benefit of mineralogists, as a reward to the industry and hard toil of the diggers.

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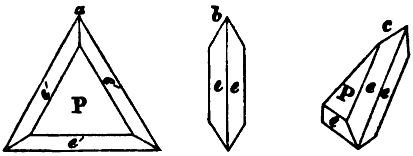
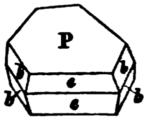
* The two large crystals above described were obtained from the very choice and beautiful collection of specimens, made with great care, and at no small expense, by Mr. Platt. This gentleman, during a most prosperous residence of two years in San Francisco, and while occupying a situation which brought him into daily and almost hourly contact with persons returning from the mines, has evinced his good taste by purchasing the most interesting specimens obtained by them. He has consequently been rewarded by the finest amateur collection hitherto brought from California. It comprises a great variety of ramified, arborescent, dendritic and other imitative forms, here and there showing crystalline faces, all of them being sometimes most fantastically joined together in the same specimen. He informs me that in obtaining this collection, he had examined gold to the amount of more than four millions of dollars.

Crystals of rare modifications.—Among the specimens collected by Mr. Tyler, I have found several rare modifications of this metal, such as come to us in their most perfect forms from Brazil. I here give figures of two of them. One, fig. 1, (*a*, *b*, *c*,) represents a compound form produced by the union of two opposite sections, or segments, of an emarginated octahedron; a form not unfrequently presented by octahedral spinelle. The other, fig. 2, has the apparent form of irregular six-sided tables, with truncated edges, and is a modification of the same form. They are tolerably well represented by the figures referred to, but the planes of the dodecahedron (*e*) are less conspicuously defined on the real crystals, owing to their extreme thinness, and their edges being rounded off, or otherwise disfigured. For this reason, we can distinguish but two of the primary octahedral planes on any of these crystals. Crystals somewhat resembling

1.



2.



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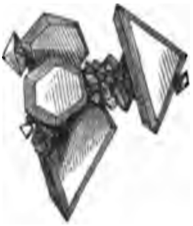
[*] They differ in regard to silver and iron, some adopting the cube, and others the octahedron, as the primary.

[†] Cronstedt, in his Mineralogy, says, "I have procured in Transylvania a specimen of cubic native gold, but I have never seen it any where else." In Levy's enumeration of the splendid Turner collection formed by Henry Heuland, eight examples are given of the regular octahedron, and only two of the cube, one of these being from the very locality Cronstedt speaks of.

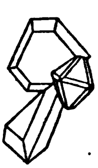
fig. 2, have been brought from Brazil and Siberia; they had the same flattened form of six-sided tables, but they are the result of a different kind of modification, and are not macles. Dufrénoy and Levy,* have each given a figure of a very perfect example of the modification here referred to (*triforme* of Haüy) derived from the cube, octahedron and dodecahedron; and I was at first, inclined to regard my crystals as the same, only more deeply truncated on the solid angles *a*, as lettered by Dufrénoy. Further examination however, proved them to be the same macled combination as fig. 1, with the additional replacements indicated by the letters *b*, which have changed the triangular faces P, and the whole crystal, into a hexagonal figure as above represented. These new planes are sometimes unequally extended, and roughened by inequalities, while the primary faces P, are perfectly smooth and brilliant.†

Some of the unmodified macles, as shown in different positions by fig. 1, *a*, *b*, *c*, are very distinctly formed, the edges between *e e*, uniting the two segments of the octahedron, being well defined. This is the most strikingly shown on the largest of these crystals, the lowest one of the group represented by fig. 3.‡ Owing to its position, it is only partially visible in the group as here drawn, and fig. 4 is intended to show it as it appears on the opposite side of the specimen in juxtaposition with two other crystals, one a very beautiful and smooth planed octahedron with emarginated edges. Dufrénoy has described a macle of gold quite similar to fig. 1, and it may be seen figured in the volume of elegant and copious crystallographic illustrations which accompany his treatise.§ It came from Matto-Grosso, in Brazil, and is in the collection of the School of Mines, Paris. It differs from the example here described, in exhibiting more of the planes of the octahedron and dodecahedron. Fig. 5 is a copy of his figure, but regarding the octahedron as the primary form of gold, I have, besides conforming his lettering to the notation of Phillips, made primary planes of those which he gives only as secondaries of the cube.

3.



4.



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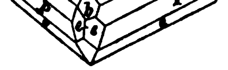

It should be observed that as nearly all of these crystals show the effects of more or less abraded action, it is often difficult to distinguish planes confined within such narrow limits, and which are too small or too rough to admit of accurate measurement. We can hardly expect to see many perfect crystals from California, until the rocks themselves are systematically explored, from whence have proceeded the millions of fragments that are now scattered over the plains and valleys. We may then, from the indications already afforded, look for crystals of gigantic dimensions, and possessing all their native unaltered beauty.

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* Fig. 576, plate 144, of Dufrénoy's, and fig. 8, plate 47, of Levy's Atlas of Plates.

† In the Turner collection there is a single macle crystal answering almost exactly to fig. 2, and Levy has figured it in his Atlas, plate 47, fig. 4.

‡ This group represents the figures as magnified to about twice their natural size.

§ Atlas, plate 145, fig. 581.

Boston, May 17, 1850.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Diffusion of Liquids;* by Professor Graham, F.R.S., (Proc. Roy. Soc., Phil. Mag., Feb., 1850, vol. xxxvi, p. 139.)—The apparatus used in studying the diffusion of salts and other substances into water was very simple. It consisted of an open phial to contain the solution of the salt to be diffused, which was entirely immersed in a large jar of pure water, so that the solution in the phial communicated freely with the latter. Phials cast in a mould of the capacity of four ounces of water, or more nearly 2000 grains, were generally employed, which were ground down to a uniform height of 3·8 inches. The neck was 0·5 inch in depth, and the aperture or mouth of the phial 1·25 inch in diameter. The phial was filled up with the solution to be diffused till it reached the point of a pin dipping exactly 0·5 inch into the mouth of the bottle. This being the solution cell or bottle, and the external jar the "water-jar," the pair together form a "diffusion cell." The diffusion was stopped, generally after seven or eight days, by closing the mouth of the phial with a plate of glass, and then raising it out of the water-jar. The quantity of salt which had found its way into the water-jar—the diffusion product as it was called—was then determined by evaporating to dryness.

The characters of liquid diffusion were first examined in detail with reference to common salt.

It was found, first, that with solutions containing 1, 2, 3 and 4 per cent. of salt, the quantities which diffused out of the phials into the water of the jars, and were obtained by evaporating the latter, in a constant period of eight days, were as nearly in proportion to these numbers, as 1, 1·99, 3·01 and 4·00; and that in repetitions of the experiments, the results did not vary more than $\frac{1}{40}$th part. The proportion of salt which diffused out in such experiments amounted to about $\frac{1}{8}$th of the whole.

Secondly, that the proportion of salt diffused increases with the temperature; an elevation of 80° F. doubling the quantity of chlorid of sodium diffused in the same time.

The diffusibility of a variety of substances was next compared, a solution of 20 parts of the substance in 100 water being always used.

Some of the results are as follows, the quantities diffused being expressed in grains: chlorid of sodium 58·68, sulphate of magnesia 27·42, sulphate of water 69·32, crystallized cane-sugar 26·74, starch-sugar 26·94, gum-arabic 13·24, albumen 3·03. The low diffusibility of albumen is very remarkable, and the value of this property in retaining the serous fluids within the blood-vessels at once suggests itself. It was further observed, that common salt, sugar and urea, added to the albumen under diffusion, diffused away from the latter as readily as from their aqueous solutions. Urea itself is as highly diffusible as chlorid of sodium.

In comparing the diffusion of salts dissolved in 10 times their weight of water, it was found that isomorphous compounds generally had an equal diffusibility, chlorid of potassium corresponding with chlorid of ammonium, nitrate of potash with nitrate of ammonia, and sulphate of magnesia with sulphate of zinc. The most remarkable circumstance is that these pairs are "equi-diffusive," not for chemically equivalent quantities, but for equal weights simply. The acids differed greatly in diffusibility, nitric acid being nearly four times more diffusive than phosphoric acid; but these substances also fell into groups, nitric and hydrochloric acids appearing to be equally diffusive; so also acetic and sulphuric acids. Soluble sub-salts and the ammoniated salts of the metals present a surprisingly low diffusibility; the quantities diffused in similar circumstances of the three salts, sulphate of ammonia, sulphate of copper, and the blue ammonio-sulphate of copper being very nearly as 8, 4 and 1.

When two salts are mixed in the solution-cell, they diffuse out into the water atmosphere separately and independently of each other, according to their individual diffusibilities. This is quite analogous to what happens when mixed gases are diffused into air. An important consequence is, that in liquid diffusion we have a new method of separation or analysis for many soluble bodies, quite analogous in principle to the separation of unequally volatile substances in the process of distillation. Thus, it was shown that chlorids diffuse out from sulphates and carbonates, and salts of potash from salts of soda; and that from sea-water the salts of soda diffuse out into pure water faster than the salts of magnesia. The latter circumstance was applied to explain the discordant results which have been obtained by different chemists in the analyses of the water of the Dead Sea, taken near the surface; the different salts diffusing up into the sheet of fresh water, with which the lake is periodically covered, with unequal velocity.

It was further shown that chemical decompositions may be produced by liquid diffusion; the constituents of a double salt of so much stability as common alum being separated, and the sulphate of potash diffusing in the largest proportion. In fact the diffusive force is one of great energy, and quite as capable of breaking up compounds as the unequal volatility of their constituents. Many empirical operations in the chemical arts, it was said, have their foundation in such decompositions.

Again, one salt, such as nitrate of potash, will diffuse into a solution of another salt, such as nitrate of ammonia, as rapidly as into pure water; the salts appearing mutually diffusible, as gases are known to be.

Lastly, the diffusibilities of the salts into water, like those of the gases into air, appear to be connected by simple numerical relations.

These relations are best observed when dilute solutions of the salts are diffused from the solution-cell, such as 4, 2 or even 1 per cent. of salt. The quantities diffused in the same time from 4 per cent. solutions of the three salts, carbonate of potash, sulphate of potash, and sulphate of ammonia, were 10·25, 10·57, and 10·51 grains respectively; and a similar approach to equality was observed in the 1, 2, and 6⅔ per cent. solutions of the same salts. It also held at different temperatures. The acetate of potash appeared to coincide in diffusibility with the same group, and so did the ferrocyanid of potassium. The nitrate of potash, chlorate of potash, nitrate of ammonia, chlorid of potassium and chlorid of ammonium formed another equi-diffusive group. The *times* in which an equal amount of diffusion took place in these two groups appear to be as 1 for the second to 1·4142 for the first, or as 1 to the square root of 2. Now in gases, *the squares of the times* of equal diffusion are *the densities of the gases.* The relation between the sulphate of potash and nitrate of potash groups would therefore fall, to be referred to the diffusion molecule or diffusion vapor of the first group having a density represented by 2, while that of the second group is represented by 1.

The corresponding salts of soda appeared to fall into a nitrate and sulphate group also, which have the same relation to each other as the potash salts.

The relation of the salts of potash to those of soda, in times of equal diffusibility, appeared to be as the square root of 2 to the square root of 3; which gives the relation in density of their diffusion molecules, as 2 to 3. Hydrate of potash and sulphate of magnesia were less fully examined, but the first presented sensibly double the diffusibility of sulphate of potash, and four times the diffusibility of the sulphate of magnesia. If these times are all squared, the following remarkable ratios are obtained for the densities of the diffusion molecules of these different salts, each of which is the type of a class of salts, hydrate of potash 1, nitrate of potash 2, sulphate of potash 4, sulphate of magnesia 16, with nitrate of soda 3, and sulphate of soda 6.

In conclusion, it was observed, that it is these diffusion molecules of the salts which are concerned in solubility, and not the Daltonian atoms or equivalents of chemical combination; and the application was indicated of the knowledge of the diffusibilities of different substances to a proper study of endosmose.

2. *On the Occurrence of Formic Acid in Stinging Nettles;* by Dr. Gorup-Besanez, (Journ. für Prakt. Chem., xlviii, p. 191; Chem. Gaz., Jan. 1, 1850, p. 8.—Some time ago, F. Will showed, by microchemical and microscopical experiments, that the fluid in the hairs of the so-called procession-caterpillar (*Bombyx processionaria*), which causes an inflammation of the skin, as well as the liquid in the poisonous organs of some insects, is nothing else than formic acid. It became highly probable therefore that formic acid would also occur in the vegetable kingdom already formed; and the first class of plants which was thought of was that which, by means of stinging hairs of similar organs, produces an analogous effect to the sting of certain insects.

About a pound of the collected plants *Urtica urens* and *dioica*, was cut small and pressed, and submitted to distillation with about four times the quantity of water and a few drops of concentrated sulphuric acid.

The distillate was opalescent; a few oil-drops floated on its surface; it had a very offensive odor and a scarcely perceptible acid reaction. Mixed with carbonate of soda and evaporated to dryness in the water-bath, it furnished a brownish mass, a very small portion of which was deliquescent, the greater part consisting of the excess of carbonate of soda.

This mass was now very cautiously decomposed in a glass retort by the gradual addition of dilute sulphuric acid, when a distinctly acid distillate was obtained in the well-cooled receiver, which, neutralized with ammonia, gave all the reactions characteristic of formic acid. This experiment however did not appear to me to furnish a satisfactory proof of the presence of ready-formed formic acid in the plant, as formic acid can be *produced* from the most different organic substances by concentrated sulphuric acid; and it was possible that in the present case the formic acid might have been produced by decomposition towards the end of the operation.

Five pounds of stinging nettles were therefore distilled with a corresponding quantity of water without any addition of sulphuric acid, and a product obtained perfectly similar to the one above mentioned. It was neutralized with carbonate of soda, evaporated to dryness, the residue decomposed with dilute sulphuric acid, and the acid distillate digested with carbonate of lime, in order to avoid the excess of carbonic acid and excess of alkali, which rendered the reactions very indistinct, and filtered. The yellowish solution, concentrated in the water-bath, proved to be formiate of lime. It reduced salts of silver and mercury, gave with sulphuric acid the characteristic odor of formic acid, and with sulphuric acid and alcohol the still more characteristic smell of formic ether; oxalate of ammonia showed the presence of lime.

The amount of formic acid present in stinging nettles is certainly small; but this will not appear surprising, if we suppose that this acid is contained only in the stinging hairs, an assumption which is confirmed by the microscopic observations of Will and Lucas. When, for instance, solution of silver is added to the plant under the microscope, and a gentle heat applied, reduction always first occurs at the extremity of the stinging hair.

3. *Method of Preparing Theine;* by H. Heinsius, (Scheidk. Onderzoek., part v, p. 318; Chem. Gaz., March 15, 1850, p. 119.)—Stenhouse has recommended the preparation of theine from the extract of tea according to Mohr's method. The following is still more simple:—Old spoiled tea is placed in an iron pot, which is covered with filtering-paper, and the whole then covered with a cylindrical paper cap. The temperature is now cautiously and gradually raised, when a sufficient quantity of pure theine will be found to have collected on the paper.

4. *Test of the Presence of Sugar;* (L'Institut, No. 846.)—M. Maumené has mentioned a new reagent for ascertaining the presence of sugar in certain liquids. It is the bichlorid of tin. He announces his having observed, contrary to the statement of Liebig, that the chlorid acts on sugar even in the dry state. A temperature of only 100° C., is necessary for determining the reaction; and even in the cold it is produced after some time. In either case it forms a brown matter partly

soluble in water—caramel—which is brilliant black when dried. If the solution of sugar and bichlorid of tin are left to spontaneous evaporation at the ordinary temperature, the color soon becomes brown, and gradually deepens; and at the end of a year or eighteen months, it is changed to a uniform jelly of a lustrous black color. The same result takes place more rapidly on evaporating the solution by heat.

A test cloth of some woollen fabric, such as white merino, is to be applied for three or four minutes in a solution of one pint bichlorid of tin and two pints of water, the liquid allowed to drain off and the merino dried in a water-bath. For testing urine, a drop of the urine is to be put on a strip of the stuff, and held over a red hot charcoal or a candle, the presence of sugar is detected by a black stain.

Such is the delicacy of this test that ten drops of diabetic urine in about six cubic inches of water are capable of staining the merino a brownish black. Paper, linen, etc., being darkened by the chlorid cannot be used in place of wool. Ordinary urine and its constituents are not darkened by this test.

Bichlorid of mercury, chlorid of antimony, and other chlorids may be used in place of bichlorid of tin. They act by depriving the sugar of water and forming a caramel containing more carbon than ordinary caramel. Different sugars act in the same manner, and other analogous compounds, as ligneous fibre, cotton, paper, starch.

The author also suggests that the reaction of sugar and oxymuriate of tin may produce a brown paint that will become very important in the arts.

5. *On Iodine in fresh water Plants;* by Ad. Chatin, (L'Institut, 847.)—It is known that iodine has been detected by Müller in the cress, "*Nasturtium officinale*," a fresh water plant. But it does not appear to be understood that it occurs also in other plants growing in fresh waters. M. Chatin has examined numerous species, growing apart from any saline waters or sources, and has ascertained that it is of frequent occurrence. He examined with success the cress about Paris, and on extending his researches, found it in the following species.

	Iodine reaction.
Potamogeton crispum, stagnant waters of Gentilly,	traces.
" *pectinatum*, the Seine, near St. Cloud,	strong.
Arundo phragmites, marshes near Meudon, . .	traces.
" " marshes of St Quentin, ...	strong.
Scirpus lacustris, Meudon, ...	traces.
" " St. Quentin, ...	strong.
Typha latifolia, St. Quentin, ...	"
Littorella lacustris, St Quentin, ...	"
Ranunculus aquatilis var. *heterophyllus*, pools of water of Satory, ...	traces.
Sagittaria sagittifolia, the Seine, near Neuilly, . .	strong.
Chara fœtida, turfy waters, Gentilly, ...	traces.
Conferva crispata, Seine, near St. Cloud, ...	strong.
Pontinalis antipyretica, pond near Charenton, .	"
Nasturtium amphibium, Meudon, ...	traces.
Gratiola officinalis of commerce, ...	"
Menyanthes trifoliata, Meudon, ...	"

Olisma plantago, Meudon,	traces.
Stratiotes aloïdes, pond, Marly,	"
Acorus calamus of commerce,	"
Veronica beccabunga of commerce,	"
Phellandrium aquaticum of commerce, the fruit,	"
Inula helenium of commerce,	"
Symphytum officinale of commerce,	"
Rumex nemorosus, swamp on the Seine, near Neuilly,	"
Potentilla anserina, " " "	"
Potentilla supina, marsh, St. Quentin,	"
Polygonum hydropiper of commerce,	"

Mr. Chatin concludes :—

(1.) That those plants growing in running waters, or on the borders of large bodies of water which may be strongly agitated by the winds, contain more iodine than those of stagnant waters.

(2.) That the proportion is very small in species that are imperfectly submerged or only at intervals.

(3.) That the proportion of iodine appears to be independent of the nature of the plant or its place in the natural system.

The anti-scrofulous effects of the cress, Veronica, Phellandrium, &c., are explained by the presence of iodine.

6. *Analysis of certain gold-colored Bronze Antiquities found at Dowris, near Parsonstown, in the King's County, Ireland;* by THOS. L. COOKE, (Royal Irish Acad.; Chem. Gaz., No. 181, p. 176.)—The articles were part of a celt and a portion of a horn. The golden hue of these ancient bronzes suggested to some the idea of an admixture of zinc, an ingredient never yet observed in ancient bronzes. Such was not the fact, as may be seen from the analysis. The specific gravity of the celt was 8·767. The author details his process for separating copper, tin and lead, which it is unnecessary to repeat at present.

	The celt consisted of	The horn consisted of
Copper,	85·232	79·345
Tin,	13·112	10·873
Lead,	1·142	9·115
Sulphur and carbon,	0·150	——
Loss	0·364=100.	0·667=100.

The author notices the loss of copper in the vapor of nitrous acid, which he endeavored to avoid by passing the gas evolved in the action of the nitric acid on the alloy (contained in a small tubulated retort) through ammonia solution in small Woulf's bottles. He also notices the very fine qualities of toughness and of hardening acquired by this alloy when hammered, enabling it to cut not only flesh but even bone. It also takes a fine polish.

7. *Mannite, its atomic Weight and Compounds;* by Dr. W. KNOP, (Pharm-Cent. Blatt., Nov., 1849, and Jan., 1850; Chem. Gaz., Mar. 1st, and April 15th, 1850.)—The author shows that the lead compounds of Favre are mere mixtures of basic lead salts with uncombined mannite, and therefore give no aid in determining the atomic weight. No combinations with acids seem to give a favorable result—but at last a compound of formic acid was obtained, curious for the manner of its formation. Crystallized *oxalic* acid and mannite fused together at 230°,

and then allowed to remain for several hours at about 212°, gave off large quantities of formic and carbonic acids. The nearly colorless syrup cooled to a transparent mass, soluble in alcohol of 0·83, in which mannite is nearly insoluble. The solution soon decomposes into formic acid and mannite. No true salts would be formed, but the compound was found to be one equiv. of formic acid and one of mannite estimated at $C_6 H_7 O_6$.

The author in his first paper points out the nitric mannite as most suitable for determining the atomic weight. In his second paper he discusses the analysis of Strecker, and agrees with him that it is sex-nitrated, its formula will then be $C_{12} H_8 O_{12}+6NO_4$. The reduction by metals and by sulphuret of ammonium is so unlike that of ordinary nitric compounds, that Dr. Knop brings it as a proof, that nitric acid is contained as such, and not as hyponitric acid. It must be remembered however, that chemists do not generally consider that hyponitric acid as such, is contained in these compounds.

For the preparation of explosive mannite the process of Stenhouse is said to be the best. Mannite is to be dissolved in very cold fuming nitric acid in the proportion of half an ounce to 2 ounces of acid—cold sulphuric acid is then added, until white grains cease to deposite. The mixture to be poured into a large quantity of water—the crude product dissolved in boiling alcohol and again poured into a quantity of cold water—after some time the mannite cakes and may be filtered and washed. G. C. SCHAEFFER.

8. *On Dulcose, a Homologue of Grape Sugar;* by A. LAURENT, (Comptes Rendus, Jan., 1850.)—This is a new sugar from Madagascar, of uncertain origin. After fusion its formula is $C_{28} H_{28} O_{24}$, differing from grape sugar by $C_4 H_4$. When dissolved, it takes up 3 equivalents of water. A crystallized compound has been obtained with 4 equiv. of water.

By the action of nitric acid on dulcose, mucic acid is formed. This sugar, which has but a slightly sweetish taste, is said to be without action on polarized light and to be incapable of alcoholic fermentation.

According to Gerhardt, the erythro-mannite obtained by Dr. Stenhouse, from certain lichen, may, on the supposition of a slight error in the analysis, be considered as a homologue of mannite, which it resembles in its properties. This view however, would make the compounds with nitric acid, sex-nitric instead of quinqui-nitric, as stated by Dr. Stenhouse. Since the discovery of Strecker that nitric mannite is in fact, sex-nitric, this supposition becomes highly probable.

The discovery of a homologue of sugar opens a new field of enquiry, while it gives additional confirmation, if any were needed, to the views of MM. Gerhardt and Laurent on this subject. It is possible that some of the known varieties of sugar, may, on more careful examination, prove additional examples of homologues. G. C. S.

Among other recent investigations in connection with the subject of sugar we may mention the following:—

9. *Sugar in the Liver.*—BEQUARD and BARRESWILL have demonstrated the presence of sugar in the liver of animals, even where saccharine or amylaceous food forms no part of their diet. It is found in no other organ. G. C. S.

10. *Sugars of Honey.*—M. Soubeiran has demonstrated the presence of three sugars in honey. 1st, ordinary glucose. 2nd, a sugar with right handed rotation, and alterable by acids. 3d, a sugar with left handed rotation to an amount nearly double that of the last. This is called liquid sugar of honey; it is uncrystallizable, may be converted into transparent solid sugar which melts with great ease; it is easily acted upon and destroyed by alkalies. This sugar has been kept for years without change or crystallization. G. C. S.

11. *Sugar in the flowers of Rhododendron ponticum.*—Dr. B. Slhamer has proved that this is pure cane sugar. The honey collected by bees from these flowers is said by Tournefort to possess narcotic properties. No such substance however could be obtained by the author, and not a trace of nitrogen could be detected. G. C. S.

12. *Sugar of milk in the Cotyledons of seeds.*—H. Braconnot states that he has determined the presence of sugar in the cotyledons of the acorn and other seeds, and also of the other constituents of milk. These substances being found in the egg, we have a remarkable analogy in the instrument provided for the infant animal and plant. G. C. S.

13. *Production of Sugar in the urine by wounding the brain.*—M. Bernard has found that by wounding a certain portion of the floor of the fourth ventricle, the urine in an hour and a half or two hours, resembles that of diabetes, becoming clear and abundant with a very large quantity of sugar in solution. The blood also contains a large quantity of sugar. The portion of the fourth ventricle in which a wound produces this effect, is confined to a small space a little above the origin of the 8th pair of nerves.

The results of this curious discovery promise to throw new light upon the process of digestion. G. C. S.

II. Mineralogy and Geology.

1. *Notice of Trilobites in the Cabinet of Dr. Julius S. Taylor,* (in a letter addressed by Dr. Taylor to the Editors.)—Believing that any information upon the subject of trilobites is at all times acceptable to the scientific world, I venture to tell you of a remarkable portion of one found a few days past by me. It is an "Isotelus megistos," and I think presents the most remarkable evidence of their gigantic size, of any specimen now extant. It was found in our blue limestone strata, and presents the tail or "post-abdomen," and seven of the segments across the back, nearly entire. Its width is 9¼ inches, and its length a little exceeds this. Thus you perceive, that if we had the other segment and the head, we should have one entire that would measure at least 18½ inches in length and 9¼ in breadth!

I see that Mr. Barrande of Prague is of the opinion that trilobites change greatly according to age. Of the correctness of that opinion I should have some doubts, as I have a variety of the Isotelus megistos from half an inch, up to the gigantic one above mentioned, and I find no difference in them either in proportions or segments, each having eight, and each portion being equal in length. I have also numerous specimens of the Calymene senaria, from the size of the smallest pea up to the size of one inch in width, and in them I find no difference. And of several other varieties, I have many portions of different ages, all of which have exact resemblance. Of the Calymene Blumenbachii, I have them from one inch to three and a half in length, more or less perfect, and in them I find no change in appearance. Thus it would appear that in our varieties, at least, we have no metamorphosis of the earliest of the moving animals. However, I have not seen his work, and the notice of it may be too short to give a correct idea of what he means.

Carrolton, Montgomery Co., Ohio, April 18, 1850.

2. *Observations on the Mica Family;* by J. D. Dana.—The Mica family includes many distinct compounds formerly confounded, and the old names have on this account become inapplicable. The species *Oblique* or *Potash mica* is not the only oblique or potash mica, and some other appellation for this species has become necessary; and the writer has therefore adopted in his system of Mineralogy the name *Muscovite* from its common appellation, Muscovy glass. The other species have similar distinctive appellations, as *Biotite*, for hexagonal mica, *Phlogopite* for a trimetric mica, *Margarodite* for a second potash or oblique mica, etc.; and it is probable that several other species besides those now known, are yet to be distinguished.

The following observations on the different kinds of mica are mainly from the volume just referred to.

Rammelsberg in his 4th Supplement (p. 76) has calculated anew the several analyses of muscovite, and lays down the formulas of the varieties. But by some oversight, he makes the ratio for the oxygen of the protoxyds, peroxyds and silica, 1 : 12 : 15 equal to ¾ : 9 : 12, as if 4 : 5 equals 3 : 4; and the formula deduced is that based on the former ratio. As the point is of some importance, we give here the ratios from his calculations, making the oxygen of the alumina 12, for better comparison with that of the silica as well as the protoxyds. A slight variation in the protoxyds, whether from impurity or not, varies largely the ratio to the other ingredients: while the ratio between the peroxyds and silica, since it is much nearer equality, is not liable to such fluctuations. The results are as follows:

	$\dot{R}$	$\bar{R}$	$\dddot{Si}$				
Utö, Rose,	1·63 :	18·62[a] :	24·68	=	1·05 :	12 :	15·91.
Broddbo, Rose,	1·42 :	17·76 :	23·95	=	0·96 :	12 :	16·18.
Fahlun, Rose,	1·39 :	18·56 :	24·01	=	0·90 :	12 :	15·52.
Kimito, Rose,	1·56 :	18·54 :	24·09	=	1·01 :	12 :	15·59.
Ochotsk, Rose,	1·44 :	17·89 :	24·52	=	0·97 :	12 :	16·45.
Zsidovácz, Kussin,	1·71 :	17·93 :	24·97	=	1·14 :	12 :	16·71.
Mean, excluding the last,					0·98 :	12 :	15·93
Mean, including the last,					1·005 :	12 :	16·06

[a] Corrected.

The mean therefore of the five analyses from which Rammelsberg deduces his ratio is very closely 1 : 12 : 16, and if Kussin's analysis be added, it gives still more nearly this ratio; moreover, the separate analyses correspond more nearly with 1 : 12 : 16 than 1 : 12 : 15. Rose's formula $\dot{K}\dddot{Si}+4\bar{Al}\dddot{Si}$, adopted by this author, is not therefore sustained by the analyses.

Neither does Kussin's analysis correspond to the ratio $1\frac{1}{3} : 12 : 15$, whence Rammelsberg derives incorrectly (but correctly from $1 : 9 : 12$) the formula $\dot{\mathrm{K}}\dddot{\mathrm{Si}}+3\dddot{\overline{\mathrm{Al}}}\dddot{\mathrm{Si}}$, but more nearly to $1\frac{1}{3} : 12 : 16\frac{1}{2}$, though probably essentially $1 : 12 : 16$, like the preceding.

A mica from Unionville, Pa., occurring in scaly granular masses, afforded J. D. Darrack, in the Laboratory of J. C. Booth, (Min., 1850, p. 357,)

$\dddot{\mathrm{Si}}$ 46·75, $\dddot{\overline{\mathrm{Al}}}$ 39·20, $\dddot{\overline{\mathrm{Fe}}}$ *trace*, $\dot{\mathrm{Mg}}$ 1·02, $\dot{\mathrm{K}}$ 6·56, $\dot{\mathrm{Ca}}$ 0·39, $\dot{\mathrm{H}}$ 4·90 = 98·82.

This gives for the ratio $1·61 : 18·32 : 24·29 = 1·05 : 12 : 15·91$ or nearly $1 : 12 : 16$.

The Abborforss mica (Svanberg) and Fuchsite (Schafhäutl) afford,

Abborforss, $3·27 : 15·06 : 20·61 = 2·60 : 12 : 16·42 = 2\frac{2}{3} : 12 : 16$.
Fuchsite, $2·33 : 17·88 : 24·91 = 1·53 : 12 : 16·32 = 1\frac{1}{2} : 12 : 16$.

The first corresponds to the ratio $2 : 9 : 12$, and formula $\dot{\mathrm{R}}^2\dddot{\mathrm{Si}}+3\dddot{\overline{\mathrm{Al}}}\dddot{\mathrm{Si}}$. Taking the Fuchsite at $1\frac{1}{3} : 12 : 16$, it gives the formula $\dot{\mathrm{R}}\dddot{\mathrm{Si}}+3\dddot{\overline{\mathrm{Al}}}\dddot{\mathrm{Si}}$.

MARGARODITE, *Schafhäutl.*—This pearly white biaxial mica and others allied have afforded the following analytical results.

Analyses: 1, Schafhäutl; 2, Delesse, (Ann. d. Mines, [4], xvi, 202, 1849); 3, 4, Brewer, of the Yale Laboratory, (Min., 1850, 359); 5, Rammelsberg, (4th Supp., 75):

	$\dddot{\mathrm{Si}}$	$\dddot{\overline{\mathrm{Al}}}$	$\dddot{\overline{\mathrm{Fe}}}$	$\dddot{\overline{\mathrm{Mn}}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Na}}$	$\dot{\mathrm{K}}$	$\dot{\mathrm{H}}$
1. Zillerthal,	47·05	34·90	1·50	—	1·95	4·07	7·96	1·45=98·88, Schafhäutl.
2. St. Etienne,	46·23	33·08	3·48	*trace*	2·10	1·45	8·87	4·12, F *trace*=99·33, D.
3. Monroe, Ct.,	49·96	32·85	*trace*	—	1·08	2·89	7·91	4·46[a], Cl 0·14=99·29, B.
4. " "	49·97	32·60	—	—	1·41	*undetermined*		4·46[a], Brewer.
5. Loc. doubtful,	47·84	32·36	3·06	—	1·28	1·55	10·25	2·43, $\dot{\mathrm{Ca}}$ 0·29=99·06, R.

[a] A mean of 4 determinations.

The ratios are as follows,

1, $3·17 : 16·35 : 24·45 = 2·33 : 12 : 17·95 = 1·16 : 6 : 8·97$
2, $2·65 : 16·46 : 24·02 = 1·98 : 12 : 17·51 = 0·99 : 6 : 8·76$
3, 4, $2·63 : 15·35 : 25·96 = 2·05 : 12 : 20·29 = 1·02 : 6 : 10·14$
5, $2·71 : 16·03 : 24·86 = 2·03 : 12 : 18·61 = 1·01 : 6 : 9·30$

Rammelsberg and Delesse agree nearly in giving the ratio $1 : 6 : 9$. Schafhäutl's has the protoxyds a little in excess, and Brewer obtained an excess of silica. But it is probable that all come under the same formula, $\dot{\mathrm{R}}\dddot{\mathrm{Si}}+2\dddot{\overline{\mathrm{R}}}\dddot{\mathrm{Si}}$. The mica of Monroe, Ct., occurs with fluor spar and topaz in large scales, aggregated into wedge shapes. G=2·79—2·81. The St. Etienne mica has G=2·817; Rammelsberg's 2·831; Schafhäutl's 2·872. In this species the oxygen ratio of the peroxyds and silica is $2 : 3$, while it is $3 : 4$ in muscovite. The *Gilbertite* of Thomson appears to be altered muscovite, or margarodite.*

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* The mineral *Gilbertite* has the aspect of a pearly white mica, occurring in scales often radiately aggregated. The following are the analyses given; 1, Lehunt, of true Gilbertite from Cornwall, (Thom. Min., i, 235); 2, Thomson, Cornwall, different locality.

	$\dddot{\mathrm{Si}}$	$\dddot{\overline{\mathrm{Al}}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Na}}$	$\dot{\mathrm{H}}$
1.	45·15	40·11	1·90	4·17	2·43	—	4·25=98·01, Lehunt.
2.	47·80	32·62	1·60	—	5·18	9·23	4·00=100·43, Thomson.

The first analysis gives for the oxygen of the protoxyds, peroxyds and silica, 2·48 : 18·75 : 23·46, whence the ratio 1·59 : 12 : 15·01. Dufrenoy deduces 2 : 12 : 16. Like

Phlogopite, (or Rhombic Mica) according to Meitzendorff's analyses has the ratio 1 : $\frac{2}{3}$: 1$\frac{2}{3}$ and formula $3\dot{R}^3\,\dddot{Si}+2\bar{R}\,\dddot{Si}$, which is the formula of idocrase. Rammelsberg places here a mica from Sala analyzed by Svanberg. The species includes brown or yellowish coppery mica from Natural Bridge, Pope's Mills, Gouverneur, and Vrooman's Lake in northern New York; a black mica from Moriah, Essex Co.; a silvery mica from Edwards, N. Y.; a transparent mica from Pope's Mills, a variety of the brown. The optical character of these micas has been observed by the writer in connection with B. Silliman, Jr.

Biotite (Hexagonal or Magnesia Mica) has the ratio 1 : 1 : 2, and formula $\dot{R}^3\dddot{Si}+(\ddot{\bar{Al}}, \bar{Fe})\,\dddot{Si}$, which is essentially the formula of garnet. A chrome magnesia mica gives the ratio $\frac{1}{2}$: 1 : 2, but whether uniaxial or not is not certain. A Pargas biotite gives, $\frac{2}{3}$: 1 : 2, and the formula $\dot{R}^2\,\dddot{Si}+\bar{R}\,\dddot{Si}$ (Rammelsberg); and a Rosendal, 1 : 1 : 2$\frac{1}{2}$, or the formula $3\dot{R}^2\,\dddot{Si}+2\bar{R}\,\dddot{Si}$.

Lepidolite or Lithia mica.—The Lithia micas have been the subject of study by Rammelsberg, and he concludes that in them as well as topaz, the fluorine replaces oxygen, or is in the same state of composition as the oxygen. There are several distinct chemical compounds included, and it is not definitely known that they are all biaxial. Brewster observes that in one lithia mica part of the specimen was biaxial and part uniaxial. The ratios given by Rammelsberg are,

a. 1 : 3 : 6=$\dot{R}\,\dddot{Si}+\bar{R}\,\dddot{Si}$—mica of Ural, Chursdorf, Utö, Rozena, Altenberg (Stein).
b. 2 : 9 : 15=$2\dot{R}\,\dddot{Si}+3\bar{R}\,\dddot{Si}$—mica of Zinnwald.
c. 1 : 2 : 5=$3\dot{R}\,\dddot{Si}+2\bar{R}\,\dddot{Si}$—mica of Juschakowa.
d. 1 : 6 : 7=$\dot{R}^3\,\dddot{Si}+6\bar{R}\,\dddot{Si}$—mica of Altenberg according to Turner.

In the Ural, Chursdorf, Utö, and Rozena micas, the fluorine is to the oxygen as 1 : 20; in the Altenberg, (Stein), 1 : 60; in the Zinnwald, 1 : 14, or 1 : 11; in the Juschakowa, 1 : 8; in the Altenberg, (Turner), 1 : 25.

The Ural mica (Turner) affords then the formula,—writing for $\dot{R}\,\dddot{Si}+\bar{R}\,\dddot{Si}$, $(R\,O+Si\,O^3)+(R^2\,O^3+Si\,O^3)$,

$$20[(R\,O+Si\,O^3)+(R^2\,O^3+Si\,O^3)]+[(R\,F+Si\,F^3)+(R^2\,F^3+Si\,F^3)];$$

and in the same way the other formulas may be written out. Making O and F isomorphous, this formula becomes,

$$[R\,(O,F)+Si\,(O,F)^3]+[R^2(O,F)^3+Si(O,F)^3].$$

Emerylite and **Euphyllite**.—These species have undergone recent re-examinations, and the species now stand as follows.

Emerylite, *J. Lawrence Smith.* Corundellite and Clingmanite, *Silliman*, Jr.—Foliated like mica; folia easily separable. Either in coarse plates or in masses consisting of aggregated spangles.

H.=3·5—4·5. G.—2·995, Silliman, Jr. Lustre pearly. Color white. Translucent, to nearly opaque. Folia brittle or slightly flexible.

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muscovite the protoxyds bear a small proportion to the peroxyds, and the ratio is very near that derived from some analyses of this species. The specimens look like a slightly altered mica. Including the water, the oxygen ratio is 1·59 : 12 : 15·01 : 2·41. The oxygen ratio for the second analysis is 4·16 : 15·24 : 24·84=1·64 : 6 : 9·78, approaching margarodite, excepting in the larger amount of protoxyds.

The relation of the species to the micas is evident; yet other analyses are desirable.

Composition.—$\dot{R}^3 \dddot{Si} + 3\bar{Al}^2 \dddot{Si} [+3\dot{H}]$=Silica 30·58, alumina 50·99, lime 13·96, water 4·47. Analyses: 1, J. Lawrence Smith, (Am. J. Sci. [2], vii, 285); 2, 3, 4, Wm. J. Craw, in the Yale Laboratory, (Silliman, Jr., Am. J. Sci. [2], viii, 379); 5, 6, ibid, (private communication); 7, C. Hartshorne, in Laboratory of J. C. Booth, (private communication from Prof. J. C. Booth); 8, Silliman, Jr., (private communication):

	$\dddot{Si}$	$\bar{Al}$	$\dot{Ca}$	$\dot{Mg}$	$\dot{Na}$	$\dot{K}$	$\dot{H}$	
1. Asia Minor,	30·	50·	13·	—	—	—	—	$\dot{Fe}$, $\dot{Mn}$, $\dot{K}$ 3, $\bar{Zr}$ 4 =100, S.
2. Village Green,	32·31	49·24	10·66	0·30	2·21	(loss)	5·27	=100, Craw.
3. “	31·06	51·50	9·24	0·28	2·97	“	5·27	=100, Craw.
4. “	31·26	51·60	10·15	0·50	1·22	“	4·27	=100, Craw.
5. “	30·18	51·40	10·87	0·92	2·23	0·54	4·52	=100, Craw.
6. Unionville,	29·99	50·57	11·81	0·62	1·62	0·85	5·14	=100, Craw.
7. “	32·15	54·28	11·36	0·05	*undetermined*		0·50,	$\bar{Fe}$ *trace*, Hartshorne.
8. North Carolina,	29·17	48·40	9·87	1·24	6·15	—	3·99,	HF 2·03=100·80, S. Jr.

Analyses 6, 7 are of the *Corundellite*, and 8, of the *Clingmanite*. The following are the oxygen ratios for the protoxyds, peroxyds, and silica:

	$\dot{R}$		$\bar{R}$		$\dddot{Si}$						
1.	4·20	:	24·42	:	15·59	=	1·08	:	6·26	:	4
2.	3·87	:	23·01	:	16·79	=	0·99	:	5·48	:	4
3.	3·43	:	23·93	:	16·14	=	0·85	:	5·93	:	4
4.	3·40	:	24·12	:	16·24	=	0·85	:	5·94	:	4
5.	4·03	:	24·02	:	15·68	=	1·03	:	6·13	:	4
6.	4·01	:	23·64	:	15·53	=	1·17	:	6·08	:	4
7.	3·65[a]	:	25·37	:	16·71	=	0·92	:	6·08	:	4
8.	3·99	:	23·92	:	15·84	=	1·08	:	6·04	:	4
					Mean	=	1·00	:	5·99	:	4

[a] Supposing the alkalies equivalent to the loss.

The mean result is quite closely 1 : 6 : 4, and the same is afforded by several of the particular results. As Dr. Smith found no water, and Hartshorne only 0·5 per cent., the species is primarily anhydrous. Including the water found by Craw in his specimens, the ratio is 1 : 6 : 4 : 1.

Commonly yields water in a matrass, with sometimes a trace of fluorine. B.B. exfoliates and emits a bright light and finally fuses on the edges.

Detected by Dr. J. Lawrence Smith, with the corundum of Magnesia, Asia Minor, and also at Naxia and Niconia. Also found with corundum at Village Green, Delaware Co., Pa.; at Unionville, Chester Co., Pa., (Corundellite); at the Corundum locality in Buncombe Co., North Carolina, (Clingmanite).

EUPHYLLITE, *Silliman*, Jr.—Structure as in common mica, but laminæ not as easily separable. Biaxial; angle between the optical axes 71½°, Silliman, Jr.

H.=3·5—4·5. G.=2·963—3·008. Lustre of cleavage surface bright pearly, inclining to adamantine. Color white to colorless; sides faint grayish sea-green or whitish. Transparent to translucent; at times opaque or nearly so. Laminæ rather brittle.

Composition.—Analyses: 1, 2, H. Erni, in the Yale Laboratory, (private communication); 3, 4, T. Garrett, in J. C. Booth's Laboratory, Philadelphia, (private communication):

	$\dddot{\mathrm{Si}}$	$\dddot{\bar{\mathrm{A}}}\mathrm{l}$	$\dddot{\bar{\mathrm{F}}}\mathrm{e}$	$\dot{\mathrm{C}}\mathrm{a}$	$\dot{\mathrm{M}}\mathrm{g}$	$\dot{\mathrm{N}}\mathrm{a}$	$\dot{\mathrm{K}}$	$\dot{\mathrm{H}}$
1. Unionville,	43·69	44·69	—	3·98	0·75	0·98	0·82	5·60=100·41, Erni.
2. "	43·45	44·98	—	4·34	0·69	*undetermined*		4·97, Erni.
3. "	45·93	48·23	0·60	3·53	2·44	—	*trace*	—=100·73, Garrett.
4. " (dif. loc.)	45·33	46·47		2·36	*trace*	—	*undet.*	—, Garrett.

The following are the oxygen ratios for the analyses:

1.	1·80 :	20·88 :	22·65	=	0·95 :	11·06 :	12
2.	1·88 :	21·02 :	22·57	=	1·00 :	11·18 :	12
3.	1·96 :	22·82 :	23·87	=	0·98 :	11·47 :	12
4.	— :	21·72 :	23·55	=	— :	11·07 :	12
			Mean,		0·98 :	11·19 :	12

The ratio 1 : 11 : 12 appears therefore to be that authorized by the analyses. As no water was found in the 3d and 4th analyses, the species is essentially anhydrous. Including the water found by Erni, the ratio becomes 1 : 11 : 12 : 3, and the formula $\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}+11\dddot{\bar{\mathrm{A}}}\mathrm{l}\dddot{\mathrm{Si}}+9\dot{\mathrm{H}}$.

It is still possible that 1 : 12 : 12 will prove to be the true ratio; and in that case the ratios for margarite, emerylite, euphyllite, and muscovite, have an obvious simple relation, they being respectively 1 : 12 : 8: 2 : 12 : 8; 1 : 12 : 12; 1 : 12 : 16.

In a matrass, often yields water. B.B. exfoliates, emits a strong light, and in the forceps fuses on the edges. Gives traces of fluorine, but none of lithia.

Occurs associated with tourmaline and corundum at Unionville, Delaware Co., Pennsylvania. The impression of the crystals of tourmaline on the lateral surface of the mica, leaves a very smooth, hard looking surface. Also in the same vicinity in aggregated laminæ, or scales; this variety afforded the analysis No. 4 above.

Recapitulation.—The following are the oxygen ratios observed among the micas, and the formulas corresponding:—

(1.) Micas having atomically as much alumina as silica, or a larger amount. These micas are harder than those of the following division, and brittle or but slightly elastic.

1. *Margarite,*	1 : 12 : 8	= 1 : 12 : 8	$\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}^2+6\dddot{\bar{\mathrm{A}}}\mathrm{l}^2\dddot{\mathrm{Si}}$
2. *Emerylite,*	2 : 12 : 8	= 1 : 6 : 4	$\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}+3\dddot{\bar{\mathrm{A}}}\mathrm{l}^2\dddot{\mathrm{Si}}$.
3. *Euphyllite,*	1 : 12 (?11) : 12		? $\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}+11\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.

(2.) Micas having atomically less alumina than silica

1. *Muscovite, a.*	1 : 12 : 16	= 1 : 12 : 16	$3\dot{\mathrm{R}}, 12\dddot{\bar{\mathrm{A}}}\mathrm{l}, 16\dddot{\mathrm{Si}}$.
b. Fuchsite,	1½ : 12 : 16	= 1 : 8 : 10⅔	
c. Abborforss,	2⅔ : 12 : 16	= 1 : 4½ : 6	$\dot{\mathrm{R}}^2\dddot{\mathrm{Si}}+3\dddot{\bar{\mathrm{A}}}\mathrm{l}\dddot{\mathrm{Si}}$.
2. *Margarodite,*	2 : 12 : 18	= 1 : 6 : 9	$\dot{\mathrm{R}}\dddot{\mathrm{Si}}+2\dddot{\bar{\mathrm{A}}}\mathrm{l}\dddot{\mathrm{Si}}$.
3. *Lepidolite, a.*	4 : 12 : 24	= 1 : 3 : 6	$\dot{\mathrm{R}}\dddot{\mathrm{Si}}+\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.
b.	2⅔ : 12 : 20	= 1 : 4½ : 7½	$2\dot{\mathrm{R}}\dddot{\mathrm{Si}}+3\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.
c.	6 : 12 : 30	= 1 : 2 : 5	$3\dot{\mathrm{R}}\dddot{\mathrm{Si}}+2\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.
d.	2 : 12 : 14	= 1 : 6 : 7	$\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}+6\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.
4. *Phlogopite,*	18 : 12 : 30	= 1 : ⅔ : 1⅔	$3\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}+2\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.
5. *Biotite, a,*	12 : 12 : 24	= 1 : 1 : 2	$\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}+\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.
b, Pargas,	8 : 12 : 24	= 1 : 1½ : 3	$\dot{\mathrm{R}}^2\dddot{\mathrm{Si}}+\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.
c, Chrome,	6 : 12 : 24	= 1 : 2 : 4	$\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}^2+2\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.
d. Rosendal,	(?) 12 : 12 : 30	= 1 : 1 : 2½	$3\dot{\mathrm{R}}^2\dddot{\mathrm{Si}}+2\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.
6. Chamouni, Delesse,	(?) 4⅘ : 12 : 19⅕	= 1 : 2½ : 4	$3\dot{\mathrm{R}}^2\dddot{\mathrm{Si}}+5\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.
7. *Lepidomelane,*	4 : 12 : 16	= 1 : 3 : 4	$\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}+3\dddot{\bar{\mathrm{R}}}\dddot{\mathrm{Si}}$.

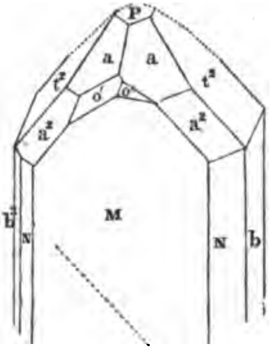
The mineral *Diphanite*, resembles margarite and euphyllite, according to Breithaupt. It has the ratio 1 : 4½ : 3¾ or 2⅔ : 12 : 10.

We have not written a formula for the muscovite. It is evident from a survey of the compounds, that there must be some more satisfactory mode of exhibiting the relations of substances, than by the formulas often made out. They frequently make seeming diversity instead of showing relationships, and tend to mislead the eye not thoroughly acquainted with the wide variation of formula consequent on a slight change of ratio.

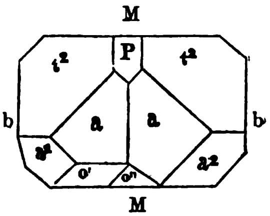
The amount of water which analyses afford varies from 0 to 5 per cent.; and as it exists variously or not at all, in micas in which the oxygen ratio is the same, there is reason for believing it the result of a partial alteration of the mica, like that which takes place in iolite. The hydrous varieties are commonly more or less wanting in transparency.

3. *Spodumene*, (Dana's Min., 1850, p. 693.)—The annexed figure of a crystal of Spodumene, from Norwich, Mass., has been made by the author from a specimen belonging to Mr. Charles Hartwell. Mr. Hartwell had measured the angles, and presented a notice of the crystal to the meeting of the American Scientific Association at Cambridge, in 1849. On examination, the author finds that the crystal is monoclinic, and further that Spodumene is actually isomorphous with Pyroxene. The annexed figure represents the crystal as it is, with a vertical plane b^3 on the right and the corresponding one on the left wanting, and also with the two planes o'' and o' unmated; moreover the back planes of the summit are absent, as the crystal is not entire or is broken on that part. The edge of intersection of o' and o'' is uncertain, as the surface has been abraded. But the rest of the faces figured are smooth, though not bright. The direction of the intersections as seen in a vertical view are shown in figure 2; the edge between o' and a^2 has a parallel direction with that between a and t^2, but that between o' and o'' is doubtful. The crystal is 2¼ inches long, 1⅝ inches wide, and 1 inch thick. The color is grayish, with a tinge of green. Besides the usual cleavages—the orthodiagonal perfect, and the prismatic scarcely less so—there are distinct traces of cleavage parallel to each orthodiagonal edge of the pyramid a—a direction pointed out on the figure by the dotted line on plane M. The surface of plane M moreover is very finely crossed by lines corresponding to this cleavage direction. The crystal is bisected along its orthodiagonal section, and on holding one of the halves up to the light it is seen to be translucent, and marked throughout with the same lines as on the surface.

1.



2.



The following are the angles, as observed with the common goniometer by Mr. Hartwell and by the author.

	Hartwell.	Author.
N : N	87°	87°
N : N (lateral angle)	93°	93°
N : M	133°	133° 30′
N : b	137°	136° 30′
N : b^3	153°	154°
M : b^3		107°
M : t^2		106°—107°
M : P		69° 40′
M : a	100° 30′	100° 30′
M : a^2	116°	116°
M : o′		127°
M : o″		140°
t^2 : t^2 (over P)		79° 30′
t^2 : b	140°	139° 45′
a^2 : t^2		140° 30′
a : a (front)	117°	117°

The crystallographic expressions for the planes are indicated in the lettering, except for the planes o′, o″, which are not determinable with certainty. In Naumann's system of notation they are:—

0P	∞P	∞P∞	∞P′∞	∞P′3	P	2P	2P′∞	3P3?	mPn
P	N	M	b	b^3	a	a^2	t^2	o′	o″

Other crystals have since been obtained by Mr. Hartwell, one of which is six inches long and nearly half this in breadth. The planes P, o′ and o″ are wanting, and the back edge of the plane t^2 is straight, there being no plane—m P. The complete description of the crystal is hence ∞P, ∞P∞, ∞P′∞, ∞P′3, P, 2P, 2P′∞. The plane ∞P′3 is seen only on the left side of plane M, as in the figure.

The specimens afforded B. Silliman, Jr., a strong lithia reaction.[*] These facts set aside an idea adopted by Dufrénoy and Pelouze, and becoming somewhat prevalent, that spodumene is a lithia feldspar; and at the same time they fail to sustain the suggestion of the writer, that spodumene is related to andalusite. The formula of spodumene best expressing its composition as ascertained by analysis, is $\dot{R}^3\bar{Si}^2+4\bar{\bar{Al}}\bar{Si}^2$ (Kobell). And if we consider the protoxyds and peroxyds as replacing one another, we find 15 of oxygen in the oxyds to 30 in the silica, which is the relation in pyroxene. With the above formula, and 3·17 for the specific gravity, the A atomic volume is 2852; the B, 168; the C, 43·2. It will be observed that 43·2 is only as much smaller than the number for pyroxene[†] as it is larger than that for andalusite. Moreover 2852 is about *three times* the corresponding number for hornblende, *four* to *four and a half* times that of pyroxene and its varieties, and *twice* that of borax.

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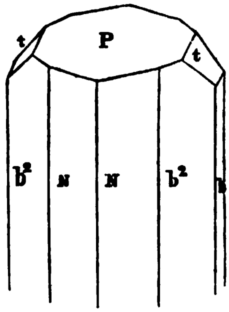
[*] The spodumene of Conway, Mass., in the same range, was tested for lithia successfully by G. T. Bowen, in 1824, and analyzed so far as to obtain $\bar{Si}$ 65·3, $\bar{\bar{Al}}$ 24·5, which agrees with the usual analyses of the species.—*This Journal*, 1824, *viii*, 120, 121.—The specific gravity of the Norwich spodumene according to a recent determination by G. J. Brush, is 3·18.

[†] See this Journal, last volume, pp. 241, and 429.

4. *Anhydrous Prehnite.*—The Anhydrous Prehnite of J. D. Whitney, (Bost. Jour. Nat. Hist., v, 487,) has been examined by Dr. C. T. Jackson, and found to contain the same per-centage of water as prehnite. In his trials he found 4·7 and 4·15 per cent. of water, and subsequently, 4·18, 4·45, 4·50, 4·41 per cent. Other specimens examined by Mr. G. J. Brush in the Yale Laboratory, afforded 4·913, 4·817, 4·864 per cent. This mineral appears therefore to be identical with ordinary prehnite. The existence of water in this variety was first ascertained in a blowpipe experiment by Mr. J. E. Teschemacher of Boston.

5. *On a new crystalline form of Staurotide, and Isomorphism of Staurotide with Andalusite and Topaz*; by J. D. Dana.—The accompanying figure represents crystals of staurotide from the spodumene locality, Norwich, Mass., which were obtained by Mr. C. Hartwell. The faces are smooth excepting sometimes t and P. The angles obtained with the common goniometer are as follows:—



N : N = 129° 20′
b^2 : b^2 (over N) = 93°
N : b^2 = 162°
P : t = 131° (129° - 132°)

The crystals are black and semi-metallic in lustre. The largest are 1½ inches in breadth.

The isomorphism of this species and andalusite is sufficiently close to merit attention.

Calculating from N : N = 129° 20′, the prism b^2 = 93° 8′. In Andalusite, the prism corresponding to the latter is 91° 20′, and this gives for the former 127° 57′. P : t in Staurotide = 131°, in andalusite 144° 50′; and the planes have therefore the axial relation of 3 : 2.

For the relation of topaz and andalusite, see last volume of this Journal, p. 407.

The atomic volume of the St. Gothard staurotide, calculated from one of Jacobson's analyses corresponding to $(\frac{4}{5}\ddot{\bar{A}}l+\frac{1}{5}\ddot{\bar{F}}e)^2\dddot{S}i$, and specific gravity 3·74, gives for the A atomic volume 536, and for the C atomic volume 38·3: for a St. Airolo staurotide, with the formula $(\frac{4}{5}\ddot{\bar{A}}l+\frac{1}{5}\ddot{\bar{F}}e)^3\dddot{S}i^2$, and specific gravity 3·7, we obtain the A atomic volume 890·5, the C value 38·7. Andalusite afforded (last volume of this Journal, p. 235) A = 962·5, C = 41·85; and topaz (loc. cit., p. 240) A = 2344; B = 42·6.

6. *Platinum of California.*—In a letter from J. E. Teschemacher, we are informed that he has detected a proportion of platinum among the grain gold of California, that will render it an important object of search in that region. In an ounce of the fine grains, he found about 50 granules which proved to be this metal. He observes that the proportion obtained is about as large as from the South American mines.

7. *Fowlerite.*—This name, applied to a variety of manganese spar or rhodonite, was not originally proposed by Prof. Shepard, as stated on p. 410 of last volume of this Journal.

III. Zoology.

1. *Remark on the Genus Nocticula of J. V. Thompson;* by J. D. Dana.—The genus Nocticula established by Thompson in his Zoological Researches, No. 2, p. 52 and plate 5, (Cork, 1829,) is closely related to the Euphausidæ.* The general form of the animal, its thoracic and abdominal appendages, and the antennæ, eyes, and short beak, are as in Thysanopoda and Euphausia; and the last abdominal segment has the acuminate character with the naked barb either side near apex, which occurs in this family.† The legs are not however represented as bifid, the outer branch and branchial appendages having been overlooked, (and in the suggestion of this error we make the "*due allowance* for drawings made at sea of such minute objects" which Thompson asks of his readers.) The number of thoracic legs is stated at sixteen, but this includes, as the drawing shows, a pair of maxillipeds. Excluding these, there will then be 7 pairs, which is the number in Thysanopoda; and it seems probable that Nocticula and Thysanopoda are identical, and if so, the former name has the precedence.

The species described and figured by Thompson, was taken in the Atlantic, between latitudes 5° 25′ S., and 29° 30′ N., and longitude 17° 18′ W., and 32° 55′ W., on the 6th, 12th, and 25th of September. It was brilliantly phosphorescent. It is called the *Nocticula Banksii*, as it is supposed by Thompson, and with apparent good reason, to be identical with the *Cancer fulgens* of Sir Joseph Banks, a species observed between Madeira and Brazil, and published with a drawing by Macartney in the Philosophical Transactions for 1810. This drawing, Thompson has copied, and in it 7 pairs of thoracic legs are represented.

2. *Observations on some Crustacea, in the collections of the Academy of Natural Sciences at Philadelphia;* by Prof. L. R. Gibbes of Charleston, S. C., (Proc. Acad. Nat. Sci., Philad., March, 1850, v, 25.)—The *Chorinus armatus* of Randall (Memoir in Jour. Ac. Nat. Sci. Philad., viii, 106,) is a Pericera, and agrees with *Pericera cornuta* of Edwards, (Crust., i, 335.)

The *Cancer mercenaria* of Say, is a *Pseudocarcinus*. It is referred by Edwards with some doubt to the genus Xantho of Leach (M. Edw., Crust., i, 399); but his description of *Pseud. ocellatus* applies in every particular to the *mercenaria*.

Grapsus longipes, *Randall*, is *Grapsus cruentatus*, according to Gibbes, and the statement that Surinam is its locality, is considered a mistake.

Grapsus hirtus, *Randall*, is *G. rudis*, M. Edw., the latter name having the priority.

Guaia ornata, *Randall*, is an *Ilia*, and a distinct species.

To the above, the Committee of the Society add—that *Macrophthalmus compressipes*, Randall, (published in 1840,) is *Gelasimus telescopicus*, Owen, Voyage of Blossom (1839), and *M. podophthalmus*, Voyage of Bonite, (1841.)

Pachygrapsus parallelus, *Randall*, is *Grapsus Thukujar*, Owen, loc. cit.; and Pagurus decorus, Randall, is *P. pictus*, Owen.

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* See this Journal, [2], ix, p. 130.

† Milne Edwards alludes to this character in the name of his Thysanopoda, *T. tricuspidata*. Ann. des Sci. Nat., xix, 1830, 454, note.—The genus Nocticula is not referred to by Edwards, either in his Memoir, or in his Hist. Nat. des Crustacés.

In most of these cases in which Dr. Randall has been forestalled, it has been by publications that were not through the press when his memoir was in course of preparation.

3. *Conspectus Crustaceorum quæ in Orbis Terrarum circumnavigatione*, Carolo Wilkes *e Classe Reipublicæ Fœderatæ Duce, lexit et descripsit* J. D. Dana. AMPHIPODA, No. I. (Proc. Amer. Acad. Arts and Sciences, ii, 201).—The following are the names of the sixty-two new species described in this paper.

Familia 1. *Orchestidæ*:—
Genus I. Talitrus: *species*, novi-zelandiæ, gracilis, ornatus.
Genus II. Talitronus, (*Dana*): *species*, insculptus.
Genus III. Orchestia: *species*, sylvicola, tenuis, rectimanus, spinipalma, scutigerula, nitida, dispar, quadrimanus, serrulata.
Genus IV. Allorchestes, (*Dana*): *species*, compressa, verticillata, hirtipalma, gracilis, peruviana, humilis, australis, brevicornis, novi-zelandiæ, intrepida, orientalis, graminea.

Familia 2, *Gammaridæ*, Sub-familia 1, *Lyssianassinæ*:—
Genus I. Lysianassa: *species*, brasiliensis
Genus II. Uristes, (*Dana*): *species*, gigas.
Genus III. Stenia, (*Dana*): *species*, magellanica.

Familia 2. *Gammaridæ*, Sub-familia 2, *Gammarinæ*:—
Genus I. Gammarus: *species*, asper, suluensis, albidus, hirsuticornis, emissitius, tenuis, furcicornis, tenellus, orientalis, quadrimanus, validus, setipes, pilosus.
Genus II. Amphitoë: *species*, peculans, fissicauda, pubescens, inæquistylis, peruviana, tenuicornis, indica, rubella, fucorum, tongensis, peregrina, brevipes, simplex, nodosa.
Genus III. Œdicerus: *species*, novi-zelandiæ.
Genus IV. Erichthonius: *species*, macrodactylus, pugnax.

Familia 3. *Corophidæ*:—
Genus I. Corophium: *species*, quadriceps.
Genus II. Clydonia, (*Dana*): *species*, gracilis, longipes.

Familia 4, *Icilidæ*:—
Genus Icilius, (*Dana*): *species*, ovalis.

4. *Oithona plumifera of W. Baird.*—The genus Scribella described in this Journal, 2nd ser., i, 227, 1846, and also viii, 279, is identical with *Oithona* of Baird, published in 1843 in the Zoologist, and the *Scribella scriba* appears to be the same species with the *Oithona plumifera.* J. D. D.

5. *On the circulation and digestion in the lower Animals;* Prof. Agassiz, (Proc. Bost. Soc. Nat. Hist, 1850, p. 206.)—Prof. Agassiz read a paper on the circulation and digestion in the lower animals, showing that the circulation in the Invertebrata cannot be compared to that of the Vertebrata.

Instead of the three conditions of chyme, chyle, and blood, which the circulating fluid of the Vertebrata undergoes, the blood of that class of the Invertebrata, which he had particularly studied, the Annelida, is, according to Wagner, simple chyle, colored chyle; the receptacles of chyle in different parts of the body are true lymphatic hearts like those found in the Vertebrata; this kind of circulation is found in the Articulata and

Mollusks with few exceptions, some Echinoderms, &c. In the Medusæ and Polyps, instead of chyle, chyme mixed with water is circulated: this circulation is found in some Mollusks and intestinal worms; it may be seen plainly in Beroë. Prof. Agassiz thinks that the embryological development of the higher animals shows a similar succession in the circulating function. He also examined the connection of respiration with the circulation: in Vertebrata, the gills are found between branches of the blood system; in Invertebrata, the chyliferous system is acted on by the respiration; the gills of fishes, then, cannot be compared to the gills of Crustacea, Articulata and Mollusks. No gills are connected with the chymiferous circulation; animals having this circulation have no true respiration; they have only tubes to distribute freely aërated water to the different parts of the body.

6. *Low State of Development of Mammals and Birds in Australia and New Zealand*, (Gould's Birds of Australia; Jameson's Jour., xlviii, 362.)—Geological researches into the structure of the globe, shew that a succession of physical changes have modified its surface from the earliest period up to the present time, and that these changes have been accompanied with variations not only in the phases of animal and vegetable life, but often in the development also of organization: and as these changes cannot be supposed to have been operating uniformly over the entire surface of the globe in the same periods of time, we should naturally be prepared for finding the now existing fauna of some regions exhibiting a higher state of development than that of others; accordingly, if we contrast the fauna of the old continents of geographers with the zoology of Australia and New Zealand, we find a wide difference in the degree of organization which creation has reached in these respective regions. In New Zealand, with the exception of a *Vespertilio* and a *Mus* which latter is said to exist there, but which has not yet been sent to this country, the most highly organized animal hitherto discovered, either fossil or recent, is a bird; in Australia, if compared with New Zealand, creation appears to have considerably advanced, but even here the order *Rodentia* is the highest in the scale of its indigenous animal productions; the great majority of its quadrupeds being the Marsupiata (kangaroos, &c.) and the *Monotremata*, (*Echidna*, and *Ornithorhynchus*), which are the very lowest of the Mammalia; and its ornithology being characterized by the presence of certain peculiar genera, *Talegalla*, *Leipoa*, and *Megapodius;* birds which do not incubate their own eggs, and which are perhaps the lowest representations of their class,* while the low organization of its botany is indicated by the remarkable absence of fruit bearing trees, the *Cerealia*, &c.

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* The genera, *Talegalla*, *Leipoa*, and *Megapodius*, form part of a great family of birds inhabiting Australia, New Guinea, Celebes, and the Phillippine Islands, whose habits and economy are most singular, and differ from those of every other group of birds which now exist upon the surface of the earth. In their structure they are most nearly allied to the *Gallinaceæ*, while in some of their actions, and in their mode of flight, they much resemble the *Rallidæ;* the small size of their brain, coupled with the extraordinary means employed for the incubation of their eggs, indicates an extremely low degree of organization.

The three species of the family inhabiting Australia, although referable to three distinct genera, have many habits in common, particularly in their mode of nidifica-

7. *New Species from Lake Superior described by M. Agassiz.*—The interesting and valuable volume lately issued by Prof. Agassiz and his associates, contains descriptions of numerous new forms of animals. We now enumerate the following species of fish described for the first time by Prof. Agassiz in this volume.

Acipenser lævis, Agass., p. 267.
" *carbonarius*, Agass., p. 271, (Plate 5, fig. 1.)
" *rhynchæus*, Agass., p. 276.
Pimelodus felis, Agass., p. 281.

PERCOPSIS, Agass., new genus. We quote the remarks of Prof. Agassiz in full respecting the very remarkable new genus of fish to which he has assigned the name *Percopsis*.

"In order fully to understand and perfectly to appreciate the characters of this genus, and the interest involved in its discovery, it is necessary to remember various relations of the different types of the whole class, which however do not constitute generic distinctions, although they bear upon the peculiarities of this new type.

"In the first place, it is a matter of no little importance that, among the fishes of former ages, we find everywhere types which differ widely from the forms of our time, and that those forms are the more different, as they belong to older geological deposits. The differences are even so great, that out of the four orders of this class, there are only two which constitute the fauna of fishes in the older formations; two orders, which in our day are comparatively reduced, I mean the Placoids and Ganoids. Moreover, the types are peculiar in all epochs. For instance, the sharks of former days, especially those of older epochs, resemble solely that curious genus of Port Jackson, New Holland, the Cestracion, which is so remarkable among the living fishes as to form a group by itself. The Ganoids, of which there are so remarkably few in the present creation, such as the gar-pike (Lepidosteus) of this continent, are not less peculiar, and in connection with those ancient Placoids, constitute the only representatives of the class of fishes throughout the earliest geological ages down to the deposits of the chalk, when new families of other orders, the Ctenoids and Cycloids, begin to make their appearance, preparatory as it were to the present development of that class, and are successively diversified with the modified adaptations of the whole class. Now the genus Percopsis is as important to the understanding of the modern types of fishes as Lepidosteus and Cestracion are to the understanding of the ancient ones, as it combines characters which in our day are never found together in the same family of fishes, but which in more recent geological ages constituted a striking peculiarity of the whole class. My Percopsis is really such an old-fashioned fish, as it shows peculiarities which occur simultaneously in the fossil fishes of the chalk epoch, which however soon diverge into distinct families in the tertiary period, never to be combined again.

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tion, each and all depositing their eggs in mounds of earth and leaves, which, becoming heated either by the fermentation of the vegetable matter, or of the sun's rays, form a kind of natural hatching apparatus, from which the young at length emerge fully feathered, and capable of sustaining life by their own unaided efforts.

"This ancient character of some of the American fishes agrees most remarkably with the peculiarity of the vegetation of this continent, which, as I have shown on former occasions, resembles also the fossil plants of prior ages.

"The geographical range of these peculiar, old-fashioned beings is also very remarkable, they living in temperate, or rather cold climates, when their earlier representatives lived in warmer epochs.

"The most striking features of the fishes of the tertiary period and those of our time consist in their belonging to two groups of the class only; one, the Ctenoids, with rough, combed scales, in which the respective representatives have also prominent serratures on prominent spines upon the head, in the operculum in particular, and in the fins; the other, the Cycloids, smooth, with simple scales with an entire margin, in which some few types however have also spinous fins.

"Now my new genus, Percopsis, is just intermediate between Ctenoids and Cycloids; it is, what an ichthyologist, at present, would scarcely think possible, a true intermediate type between Percoids and Salmonidæ.

"The general form of this genus reminds us of the common perches, but it is easily distinguished from them, by the fact that its head and the opercular apparatus are smooth and unprovided with denticulations, as also by the presence of a small adipose fin, as in the salmons. The anterior dorsal is also a small fin, composed of soft branched articulated rays, as in the salmons. The ventral fins are placed at the middle of the abdominal cavity, as in the Abdominales in general. The scales, however, are truly serrated as in the Percoids, a structure which, as far as I know, does not occur in any of the Abdominales. The conformation of the mouth is also as in the Perches, that is to say, the intermaxillaries form alone the upper margin of the mouth, and the maxillaries stand behind as a second arch, but the vomer and palate are entirely destitute of teeth.

"This fish, of which I shall publish a full anatomy, should be considered as the type of a distinct family, under the name of *Percopsides.*"

Species *Percopsis guttatus.*

The other new species described are:—

Grystes fasciatus, p. 295.
Cottus Richardsoni, p. 300.
Cottus Franklini, p. 303.
Boleosoma maculatum, p. 305, plate iv, fig. 3.
Pileoma zebra, p. 308.
Gasterosteus nebulosus, p. 310, pl. iv, fig. 4.
Gasterosteus pigmæus, p. 314, pl. iv, fig. 1.
Esox Boreus, p. 317.
Lota maculosa, p. 325.
Salmo Siscowet, p. 333, pl. i, fig. 3.
Coregonus sapidissimus, p. 344.
Coregonus latior, p. 348.

RHINICHTHYS, Agass., new genus. This new genus contains small Catostomi whose essential character is as the name indicates, to have a conical prolongation of the rostrum.

***Rhinichthys marmoratus*, p. 354, pl. ii, figs. 1 and 2.**
***Catostomus Forsterianus*, p. 358.**
" *Aurora*, p. 360, pl. ii, figs. 3 and 4.
Alburnus rubellus, p. 364, pl. iii, figs. 1–3.
Gobio plumbeus, p. 366.
Leuciscus frontalis, p. 368, pl. iii, fig. 4.
" *gracilis*, p. 370.

Besides the above, the work contains descriptions of three reptiles by Agassiz, *Hylodes maculatus*, *Rana nigricans*, and a species of *Crotophorus;* of numerous new Coleoptera by Prof. John L. Le Conte, besides a full catalogue of the species obtained, with various observations; a catalogue of the shells, with descriptions of some species; a catalogue of the birds, by J. E. Cabot; descriptions of some new Lepidoptera, by T. W. Harris.

IV. MISCELLANEOUS INTELLIGENCE.

1. *Prof. C. U. Shepard, on Meteorites.*—We have received from the author the following abstract of Prof. Shepard's report on Meteorites, read before the American Association for the Promotion of Science, at their March meeting in Charleston, S. C. He first described a very peculiar meteoric stone which was seen to fall at Richland, South Carolina, during a violent thundergust in the summer of 1846. The stone was almost perfectly round, $2\frac{1}{10}$ inches in diameter, and weighed $6\frac{1}{2}$ oz. The exterior was coated by a dark reddish brown glaze. The interior presented the fracture and color of ordinary fire-brick. Sp. gr. 2·32. It consisted of

Silica,	80·420
Alumina,	15·680
Protox. iron,	2·513
Magnesia,	0·700
Lime,	0·500
	99·813

No examination was made for alkalies.

Prof. S. next described the recently fallen stone of Cabarras County, N. C., (Oct. 31, 1849,) of which some account has already been given in this Journal.[*] The entire stone (now weighing $18\frac{1}{2}$ lbs.) was exhibited to the meeting. The general figure is that of a low, irregular, four-sided pyramid, truncated at the summit, and having for a base (which is by far the broadest plane) a somewhat rounded, undulatory surface. The crust is thin, black and strongly coherent. It is exceedingly tough; in this respect fully equalling most trappean rocks. Its ground color is of a dark bluish-grey, stained with fine rust points, and mottled with rounded grains and crystals of a lighter colored mineral, rendering the mass when closely viewed, sub-porphyritic. It resembles in structure most nearly, the rare stone which fell at Tabor in Bohemia, July 3d, 1753. Sp. Gr. = 3·60...3·66.

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[*] [2] Vol. ix, p. 143.

It consists of

Nickeliferous iron, (with chromium,)	6·320
Magnetic pyrites,	3·807
Silica,	56·168
Protoxyd iron,	18·108
Magnesia,	10·406
Alumina,	1·797
	96·606
Traces of lime, soda, potassa and loss,	3·394
	100·000

He concluded his contributions to American localities by a description of the meteoric iron of Ruff's mountain, Newberry, S. C., lately brought to light by Dr. Wells of New Haven. In noticing the internal structure of this beautiful iron, Prof. S. remarked that it resembled those of Texas and Carthage, Tenn., more closely than any others with which he was acquainted, although it differed from these by presenting here and there small gashes or veins filled with a very peculiar pyrites which may prove a new meteoric species. Sp. Gr. of internal portions of the mass =7·01...7·10; of exterior (where it is mingled with magnetic oxyd of iron) 5·97...6·80. Composition,

Iron,	96·000
Nickel,	3·121
Chromium, sulphur, cobalt, magnesium and chlorine,	traces.
	99·121

The report was concluded by some observations upon the regions over which the fall of meteorites would appear to have been most frequent. On examining the well authenticated falls of the last half century, it appears that there exist two meteoric regions or zones,—one for the new world, 11° of latitude in width, and mostly lying between the parallels of 33 and 44° of north latitude, whose length is about 25° of longitude, the region having a somewhat N. E. and S. W. direction, and conforming in some measure with the trend of the Atlantic coast; it appearing that 92·8 p. c. of all the meteoric falls for the last half century on the American continent have been deposited within that space, and with a manifest concentration over that part of it lying contiguous to the sea: while the other meteor zone upon the eastern continent, though having the same breadth and pursuing a similar northeasterly track, has more than double the length of the American region, and is very remarkably translated fully 10° of latitude northward of its fellow on the opposite side of the Atlantic. Within this zone, 90·9 p. c. of the falls for the last fifty years reported for the old world, have taken place; attended also with an obvious concentration of them over that half of the region toward the Atlantic.

In respect to meteoric iron (whose time of falling is unknown), the old world has presented us with 14 localities; of these, 11 are situated within the meteoric zone, and mostly between 46 and 52° of north latitude. The new world has already 32, whereof 23 are comprised within its meteoric region, the most of which are found near the parallel of 36°. Europe has for the last fifty years more than four times as many meteoric falls as America; and less than half the number of deposits of iron, whose time of fall is unknown. This latter circumstance is a fresh proof of the greater geological antiquity of the new world.

2. *On the increase of the Nail and the Hair in Man;* by M. Bertholdt, (L'Institut, No. 846, 93.)—The growth of the nails in children is more rapid than in adults, and slowest in the aged. It goes on more promptly in summer than in winter, so that the same nail which is renewed in 132 days in winter, requires only 116 days in summer—a fact depending on the vis vitalis, which seems to be proportional to it. The increase for the nails of the right hand is quicker than for the left; moreover it differs for the different fingers, and in an order corresponding with the length of the finger, consequently most rapidly for the middle finger, with nearly equal rapidity for the two either side of this, slower for the little finger, and slowest for the thumb. For the middle finger of the right hand the nail grew 12 millimeters in 108 days; for the small finger of the left, 9 millimeters in 152 days: the growth of all the nails of the left hand required 88 days more than for those of the right, and also there were produced in this time 3 millimeters less than on the right hand.

The growth of the hair is well known to be much accelerated by frequent cutting. It forms more rapidly in the day than at night and in the hot seasons than in the cold. But it is difficult to determine the precise rates.

It results from the tables accompanying the memoir of M. Bertholdt, that the growth of the hair and nails as well as that of the epidermis pertains to the secretions and not to the organic structure proper. For (1) the quantity of each formed corresponds very nearly with that of the peripheric secretions, especially with transpiration, it increasing in summer, whilst on the contrary, the growth and nutrition of the body are most rapid in winter, so that the weight of man, as was observed by Sanctorius, Liening, and Reil, is greatest in winter; (2) the growth of the hair least during the night accords with the diminution of all the secretions, as that of transpiration, the formation of carbonic acid, the urinary, lacteal and biliary secretions.

3. *On the Extinction of Light in the Atmosphere;* by W. S. Jacob, Esq., H.E.I.C., Astronomer, Madras. Communicated by Prof. Piazzi Smyth, (Proceedings of Roy. Soc. Edin., vol. ii, No. 36; Jameson's Jour., xlviii, 357.)—In a letter, dated Madras, November, 1849, Captain Jacob says, "I have been much interested in reading, lately, Professor Forbes's paper in the Philosophical Transactions, 1842, Part 2, on the Extinction of Light and Heat in the Atmosphere." His results agree very closely with those of my experience on the Trigonometrical Survey of India, which, though not founded on any precise measures, being still the conclusions of some years' experience, are perhaps worth noticing.

On commencing work with heliotropes in 1837, I soon found that for long distances it was necessary to enlarge the apertures *more* than in the simple ratio of the distances (though such was Colonel Everest's practice); and before the end of the first season, I had formed a scale of apertures for corresponding distances, which afterwards needed very little alteration, but when finally corrected by subsequent years' observation, stood as follows:—

Aperture. Inches.	Maximum Distance. Miles.	Maximum Distance without Absorption.
0·5	15	15
1·0	23	30
2·0	33	60
4·0	45	120
8·0	60	240

Our heliotropes were circular glass mirrors, 8 inches in diameter; and for the smaller apertures, diaphragms were used between the heliotropes and the observer. At the distances stated the light was just visible to the naked eye in clear weather, and when seen over a *valley*: if the ray *grazed* near the surface, the light was much reduced. On one occasion I employed a heliotrope at 6¼ miles, and used an aperture of ⅙ of an inch, and found it rather brighter than usual, so that probably 6½ or 7 miles would be the normal distance for that size.

This agrees well enough with the rest of the scale, but there is no need to employ a conjectural quantity; and if the rate of absorption corresponding to the above be computed, so close an agreement will be found, as may entitle the numbers to be looked on as something better than mere estimates,—as the results, indeed, of a species of observations.

The mean of the whole shows a loss of ·0610 in passing through one mile of atmosphere; with the barometer at 27·0 inches (that being about the average height of my stations), but reduced to 30·0 inches, the quantity will be ·0671.

Hence the loss of light in passing from the zenith through a homogeneous atmosphere of 5·2 miles will be ·303, or only about one per cent. less than Professor Forbes's result. And as my air was considerably drier than his (the mean humidity being not much above ·30 instead of ·56), this will probably account for the difference; and, at any rate, the agreement is much closer than could have been expected.

I once mentioned this matter to Captain Waugh, the present Surveyor-General of India, then my fellow-assistant; but he not only had not noticed the thing, but did not even apprehend my meaning. He assented to my remark on the *loss* of light in passing through the atmosphere, but asserted that the aperture should vary as the distance, thus allowing for *no* loss: 0·1 inch per mile answered, he said, for all distances that he had tried. So it might answer for the distances most usually occurring on the Survey. For 4 inches would be proper for 40 miles, and 2 inches not much too bright at 20, and it is not often that these limits would be passed. Yet it is hardly possible to conceive that he should not have noticed the different intensity of the lights; had not his opportunities been perhaps rather unfavorable, as his work lay chiefly in plains, where, as mentioned above, the light of a grazing ray is very much reduced, and the atmospheric effect would therefore be mixed up with disturbing local causes.

I myself was much astonished at first discovering that the air had so great absorbent powers, and many ideas are suggested by the fact. We see at once how easily many of the planets may be rendered habitable to beings like ourselves. Mars, *e. g.*, may enjoy a temperature little inferior to our own, by having a *less* absorbent envelop; and Venus may be kept as cool as we are, by having one *more* so.

4. *Climate of Australia;* by John Gould, Esq., F.R.S., F.G.S., &c., (Vide Gould's Birds of Australia; Jameson's Jour., xlviii, 358.)—In a country of so vast extent as Australia, spreading over so many degrees of latitude, we might naturally expect to find much diversity in the climate, and such is really the case. Van Diemen's Land, from its isolated and more southern position, is cooler, and characterized by greater humidity than Australia; its vegetation is therefore abundant, and its forests dense and difficult of access. The climate of the continent, on the other hand, between the 25th and 35th degrees of latitude, is much drier, and has a temperature which is probably higher than that of any other part of the world, the thermometer frequently rising to 110°, 120°, and even 130° in the shade; and this high temperature is not unfrequently increased by the hot winds which sweep over the country from the northward, and which indicate most strongly the parched and sterile nature of the interior. Unlike other hot countries, this great heat and dryness is unaccompanied by night-dews, and the falls of rain being uncertain and irregular, droughts of many months' duration sometimes occur, during which the rivers and lagoons are dried up, the land becomes a parched waste, vegetation is burnt up, and famine spreads destruction on every side. It is easier for the imagination to conceive than the pen to depict, the horrors of so dreadful a visitation. The indigenous animals and birds retire to the mountains, or to more distant regions exempt from its influence. Thousands of sheep and oxen perish, bullocks are seen dead by the roadside, or in the dried-up water holes, to which, in the hope of relief, they had dragged themselves, there to fall and die; trees are cut down for the sake of the twigs as fodder; the flocks are driven to the mountains, in the hope that water may there be found, and every effort is made to avert the impending ruin; but, in spite of all that can be done, the loss is extreme. At length a change takes place, rain falls abundantly, and the plains, on which, but lately, not a blade of herbage was to be seen, and over which the stillness of desolation reigned, become free with luxuriant vegetation. *Orchideæ*, and thousands of flowers of the loveliest hues are profusely spread around, as if nature rejoiced in her renovation, and the grain springing up vigorously, gives promise of an abundant harvest. This change from sterility to abundance, in the vegetable world, is accompanied by a correspondent increase of animal life; the waters become stocked with fish, and the marshy districts with frogs and other reptiles, hosts of caterpillars and other insects make their appearance, and, spreading over the surface of the country, commence the work of devastation, which, however, is speedily checked by the birds of various kinds that follow in their train. Attracted by the abundance of food, hawks, of three or four species, in flocks of hundreds, depart from their usual solitary habits, become gregarious and busy at the feast, and thousands of Ibises (*Ibis spinicollis*) and other species of the feathered race, revel in the profusion of a welcome banquet. It must not, however, be imagined that this change is effected without its attendant horrors; the heavy rains often filling the river beds so suddenly that the onward-pouring flood carries with it every thing that may impede its course, and woe to the unhappy settler whose house or grounds may lie within the influence of the overwhelming floods!

So little has as yet been ascertained respecting the climatology of Western, North-Western, and Northern Australia, that it is not known whether they also are subject to these tremendous visitations; but as we have reason to believe that the intertropical parts of the country are favored with a more constant supply of rain, as well as a lower degree of temperature, it is probable that they do not there occur.

5. *On the Resuscitation of Frozen Fish;* by Prof. O. P. HUBBARD, (communicated for this Journal.)—For a number of years, during my residence in New Hampshire, I have received from numerous sources, the statement that fish taken in the cold of winter from our ponds and thrown out upon the ice and freezing quite hard, have been restored to their usual activity when thrown again into cold water.

That they would ever have moved again if left alone is incredible; and how far and for what time a fish may be frozen and yet be restored, is not shown by experiment. I have good reasons from the character of my informers, for believing that the facts are as stated, though when repeated they are hardly credible to others; and I am much gratified in obtaining for publication, the following authentic account of a satisfactory instance.

Persons who have had similar experience are requested to communicate the facts in detail to the writer.

"Sometime in the winter of 1838 or 1839—living near a stream abounding with fish, which emptied into a pond near by, I was in the habit, daily, of catching them, (as they passed down stream,) by means of an eel-pot. This was so constructed as to receive and retain them without injury, if taken out soon, and on one occasion, the pot having remained longer than usual, so many were caught as nearly to fill the pot, and numbers perished from pressure or want of air.

It was the custom to examine the pot in the morning. On one occasion, a severe cold morning, in January I think, I took up the pot and found a considerable number were taken. These I emptied upon the snow, which was deep and so crusted with ice as nearly or quite to bear me up.

I then replaced the eel-pot in its proper bed for another draught, which took me about twenty minutes, and then gathered up my fish, exposed on the snow, into a pail or basket, and found them frozen as stiff as icicles.

I carried them home to the shop, where they remained frozen, according to my recollection, for the space of an hour and a half longer, and so stiff and inflexible that they could not be bent without cracking, as did some of their tails and fins in pulling them apart when they were congealed together. I then put them into a tub of water drawn from the well, to thaw them for dressing, and I think added a small quantity of warm water that stood upon the stove, but am not certain whether it was before or after scaling them.

After some little time, how long I cannot now say, I examined them to see if they were thawed sufficiently for dressing, and to my surprise, I found some of them as lively as when sporting in their native brooks. I called on others to view them, who had seen them while they were frozen. To them also it appeared almost incredible, but we were constrained to believe our own eyes and senses.

I think those fish were *perch* that came to life after (I cannot say death, but) freezing.

In the spring, I remark, we set the eel-pot with its mouth down stream, as then the fish are running from the pond up stream.

Yours, respectfully, PARACLETE SKINNER."

Woodstock, Conn., Dec., 1849.

6. *Geology in the State of Mississippi.*—We learn from our correspondent, Mr. M. Morris, that the Legislature of Mississippi at its recent session, has made a standing appropriation of $5000 per annum, to provide for a geological survey of the state, in connection with a geological professorship at the State University.

For years the subject had been ineffectually agitated, but the organization of a "State Geological Society" in March last—the publication of numerous popular articles on geology,—and the collection and exhibition to the Legislature of a rich cabinet of Mississippi specimens, accompanied by discussion on geology in the chamber of the House of Representatives, (out of business hours,) are among the principal causes which have brought about a result so fruitful of promise, and which we hope may be fully realized.

7. *On the Purification of Coal-Gas*; by R. LAMMING, (Athenæum, No. 1176, p. 508.)—The author's process (which has been hitherto successfully put in action at Paris,—at the Chartered Company's Westminster Works, on a small scale,—and at the Imperial Company's Haggerstone Works, on a larger scale) consists of two parts. First, the removal of the impurities from the gas; secondly, the revivification of the used material, which is again made capable of service. The purifying material is a saturated solution of muriate of iron decomposed by lime into muriate of lime and hydrated protoxyd of iron, mixed with breeze [coke in small fragments]; during the mixing, the iron becoming peroxyd (carbonate) from the oxygen of the air. On passing the gas through this material in the ordinary purifiers, the following changes take place:—The sulphuretted hydrogen combines with the peroxyd, forming water and sesqui-sulphuret of iron; the ammonia and carbonic acid join to form proto-carbonate of ammonia, which again acts on the muriate of lime to form muriate of ammonia and carbonate of lime. This proceeds until none of the peroxyd of iron and muriate of lime are unchanged. The purifier is then thrown out of connection, and a current of air passed through the used material, by which it is revivified in the manner following:—The sesqui-sulphuret of iron becomes, from the oxygen of the air, sesqui-sulphate of iron; after which this salt and the carbonate of lime decompose each other, becoming sulphate of lime and carbonate of protoxyd of iron; the latter speedily changing into hydrated peroxyd of iron, while the carbonic acid is liberated and escapes. Thus the material is brought back to its original condition, excepting that for muriate of lime has been substituted precipitated sulphate of lime, having the same affinity for carbonate of ammonia as the muriate has. In warm weather this revivification takes place in a very short time; but in winter it requires the aid of artificial heat. The same purifying material is capable of being used nine successive times without any appreciable diminution of its power, and at last becomes inefficient only from the accumulation of ammoniacal

salt, which can be removed by simply washing. The result of this process on the gas is to remove one equivalent of carbonic acid for one and a half of ammonia and one and a half of sulphuretted hydrogen. But as the gas contains more sulphuretted hydrogen than ammonia, and more carbonic acid than sulphuretted hydrogen, it is necessary to submit it a second time to a material like the former, but with an excess of hydrate of lime. Here the sulphuretted hydrogen still left seizes on the oxyd of iron, the carbonic acid being absorbed by the lime.

8. *Analysis of Water from a Hot Spring in the region of the Great Salt Lake;* by C. T. Jackson, (Proc. Bost. Soc. Nat. Hist., 1850, 224.)—This spring issues from a hill of sandstone from two to three thousand feet in height. The water is agreeable, saline, and when fresh contains a little sulphuric acid, and carbonic acid gas. The temperature is 108° F. One pint contains 44 grains of solid matter, as follows:

Carbonate of lime,	1·280
Perox. iron and trace of manganese,	0·208
Lime,	2·907
Chlorine,	18·421
Soda,	15·344
Magnesia,	2·073
Sulphuric acid,	3·748
	43·981
Loss,	·019
	44·000

9. *Wild Animals of Africa,* (Athen., No. 1176, p. 504.)—An exhibition of a novel and attractive character has just been opened at Hyde Park Corner. Mr. Roualeyn Gordon Cumming, a young gentleman of property in the Highlands, and as keen a sportsman as the Highlands has ever produced, has filled the old Chinese Gallery with the trophies of his skill—the produce of five years' shooting in the far interior of Southern Africa, many hundred miles beyond the farthest point hitherto reached by any white man. When we state that Mr. Cumming has killed eighteen lions, twenty-eight specimens of the black rhinoceros, thirty-nine of the white rhinoceros, seventy-six hippopotami, and one hundred and five elephants, our readers will know what his daring is and what his success has been. His lion's skins are the finest we remember to have seen,—worthy coverings for the king of beasts. He has at least one thousand pounds' worth of ivory in the room, and a pair of elephant's tusks measuring nine feet,—the largest known. The whole Gallery looks like a combination of a baronial hall and a furrier's shop. Antlers of the largest size and the most elegant proportions arrest the eye at every turn. The fore-feet of an elephant (exhibited on the dais) afford a noble idea of the enormous size of the herds of elephants which he had the luck to fall in with.

10. *Tin in Plumbaginous Slates.*—Dr. Jackson notices (Proceedings Boston Soc. Nat. Hist., 1850,) the fact, that the plumbaginous slates of Vermont furnish on assay, malleable grains of tin and iron, when fused in a crucible, lined with lampblack. This fact appears to Dr. Jackson to indicate the existence of tin lodes in that region.

11. *On Fossil Rain Drops*, (Proc. Bost. Soc. Nat. Hist., 1850, p. 200.) —Mr. Desor communicated some observations made by Mr. Whitney and himself in reference to the probable origin of the so-called fossil rain drops, which in this country, are found on slabs of new red sandstone, as well as Potsdam sandstone.

He said it had already been noticed by Mr. Teschemacher that these so-called rain drops, when closely examined, are found to differ in several respects from the impressions made by the rain on a beach, where each drop produces an impression surrounded by a rough crest, more or less elevated according to the force of the rain. The fossil impressions on sandstone, on the contrary, are generally flat and smooth. Besides, there is hardly a shower in which the rain drops are not numerous enough to cover the whole or nearly the whole ground, whereas the fossil impressions are generally scattered and so few in number that it seems almost impossible to ascribe them to rain.

Mr. Desor said, that whilst encamped on the border of Lake Superior, they had several opportunities of studying the action of the waves on the beach during a heavy surf, when they are driven beyond their usual range. It was noticed that when the waves retired from the higher part of the beach, where the slope was less steep, there could be seen several kinds of impressions in the act of forming, some large and flat, others small and deep, (like those which on the sea-shore are generally ascribed to worms or shrimps,) and others likewise deep, but surrounded by a sort of annular, smooth rim. These different kinds of impressions are all produced by the same cause, operating in the same way, namely, air bubbles, which are formed in the waves of the surf, when rolling over the beach. If an air bubble becomes buried in the sand, so that in order to escape it has to make its way through the new-formed stratum of sand, it forms a deep and narrow hole. If the air instead of escaping at once, bubbles up several times, then it raises around the hole a small and smooth rim, which may be compared to a miniature crater of a volcano. If, on the contrary, the air bubble remains at the surface and bursts, then it causes a flat and rather large impression. According to Messrs. Whitney and Desor, these different forms of impression arising from air bubbles, are sufficient to account for most impressions which have hitherto been considered as the effect of rain. Such impressions of air bubbles are most perfect where the slope of the beach is very gentle. Where the slope is more or less steep, the sand becomes too much hardened under the pressure of the waves to allow these delicate impressions to be produced.

A sketch was exhibited, showing these different forms of impressions, and their striking contrast with impressions of rain drops from the same beach, mouth of Carp River, Lake Superior.

Mr. Teschemacher said, that he had seen fossil rain drops, so-called, with an elevated ridge crossing them; an appearance easily explained by Mr. Desor's hypothesis, but incompatible with the supposition that they were caused by rain.

Prof. Agassiz said, that on the mud flats at Cambridge, he had noticed impressions made in the way described by Mr. Desor at Lake Superior.

12. *Expedition in Search of Sir John Franklin.*—The American Expedition equipped at the expense of Mr. H. Grinnell, a munificent merchant of New York, consists of two vessels, which are classed as brigantines in our naval service—the "Advance" of 144 tons, and the "Rescue," of 91 tons. On Mr. Grinnell's petition to Congress, the vessels have been placed under the command of the U. S. Navy, and officers and men detailed to this hazardous service. The whole is under the command of Lt. Edwin De Haven, an officer of great zeal, courage and experience. The Advance has a crew of fifteen men, and the Rescue thirteen. Both vessels were fitted with every artifice and appliance to ensure safety against extreme cold and the crushing effects of the ice packs. Passed Midshipman Griffin commands on board the Rescue. The expedition sailed on the 22nd of May, for Baffin's Bay, thence to touch at Disco Island, a Danish whaling station in latitude 70° on the coast of Greenland, where they will water before steering for Lancaster Sound and Barrows Straits, with the intention of penetrating an open sea supposed to exist between Parry's Islands and the pole. Should the ice admit they will go up the Wellington Channel, and if not they will cruise westward to Cape Walker and around Melville Island. Should all progress westward in this direction be obstructed, they will return to Baffin's Bay and attempt to enter Jones Sound or Smith's Sound, in lat. 79° N., at the extreme northern point of Baffin's Bay. Should the supposed western sea be open to the vessels, they may at their discretion go through Behrings Straits into the Pacific and communicate with the American Squadron in those seas, who have orders to furnish every assistance in their power. Lt. De Haven has discretionary power to modify or abandon this general plan, should the success of the Expedition demand it. This humane and truly liberal enterprise is solely at the individual cost of Mr. Grinnell, who has received very gratifying testimony from Lady Franklin, of her approbation of the effort. The vessels carry letters from Lady F. to Sir John Franklin, and the Admiralty have furnished Mr. Grinnell with copies of the Esquimaux vocabulary compiled by Capt. Washington, R. A.

It is also understood that not less than three Expeditions have sailed from Great Britain for the same purpose, and all fitted in the most complete manner. One of these is commanded by the renowned Sir James C. Ross.

13. *Discovery of a Comet.*—On the 1st of May, 1850, at 10^h m. t., Dr. Petersen, at the Altona Observatory, discovered a faint telescopic comet, but the weather that evening was too unfavorable for observation. Its estimated place was R. A. $19^h\,25^m$, and North Decl. $71°\ 10'$. From two days' observation, its daily proper motion was found to be, in R. A. $-1^m\ 3^s{\cdot}3$, and in declination $+9'\ 44''$.

The announcement of the discovery of a comet in Nov., 1849, (see vol. ix, p. 442,) needs confirmation.

14. *American Association for the Advancement of Science.*—The third annual meeting of this Association will assemble in New Haven on the 19th of August next, being the *third Monday* of the month, at 10 o'clock.

The easy access which may be had to New Haven from all quarters by railway, renders it highly probable that the ensuing meeting will be one of the largest and probably *the* largest ever yet assembled. Dr. Bache of Washington is the President of the year. For further particulars we refer to the circular of the Local Committee and to the advertisement to be found among our advertising pages.

15. The next meeting of the British Association for the Advancement of Science, will be held at Edinburgh in August next.

16. Mr. Edward J. Chapman has been appointed to the Professorship of Mineralogy recently instituted in University College, London.

OBITUARY.

17. Lieut. HENRY ELD, Jr., U.S.N.—Lieutenant Eld, son of Mr. Henry Eld, of New Haven, Ct., died in March last, of yellow fever on board the Ohio, soon after leaving Rio Janeiro. He was an officer of high character both as regards seamanship and general scientific attainments; and his personal qualities—his energy, decision, promptness and natural dignity, connected with the highest generosity and kindness of heart, had secured him universal esteem among his associates, and the unbounded confidence of the naval department; all who knew him, recognized him as one calculated to confer honor upon the highest stations in his profession to which he might have been called by his country. Lieutenant Eld was one of the officers of the Exploring Expedition under Capt. Wilkes, which navigated the Pacific and Southern Seas, and circumnavigated the globe during the years 1838–1842. During a large part of the cruise he was directly associated with Capt. Wilkes in the philosophical investigations, (magnetic, &c.,) carried on at different stations; and in all these duties he was known for his skill and fidelity. He was of the party under the Commander's direction that spent three weeks on the summit of Mt. Loa (14000 feet in height) for the purpose of making pendulum and other observations. (See Narrative Expl. Exp., vol. iv, chapter 4.) An exploring party through the Chikelis country in Oregon was under his command, (Narrative, vol. v, p. 123,) and he was also associated with Lieutenant Emmons and others in a tour of fifty days over the wild country between the Columbia River and San Francisco, (Narr., vol. v, chap. 6). Aboard the Peacock in the Antarctic cruise of the Expedition, Lieutenant Eld was the first to descry land. He was stationed at the crosstrees along with Lieut. Reynolds (both of them then Passed Midshipmen) on the 16th of January, 1839, when he exclaimed "land!" and Lieut. Reynolds responded almost simultaneously "so it is." After reporting it to Capt. Hudson, these officers fully confirmed the opinion with a glass; and although the announcement was at first received with hesitation by some, it was fully confirmed by subsequent events. The honor which the country claims of having anticipated the French under D'Urville, rests upon this observation. A few hours later the French had made the same discovery.

18. M. GAY-LUSSAC died in Paris on the 10th of May, aged seventy-one. He was one of the greatest of the scientific men of France. "Few men," says the *Presse*, "have led a life so useful and marked by so many labors. There is no branch of the physical and chemical sciences which is not indebted to him for some important discovery.

Alone, or in conjunction with other eminent men, particularly with Thénard and von Humboldt, he carried his spirit of investigation into them all. At a very early age he was elected a member of the Academy of Sciences. In 1810, says M. Pouillet,—speaking in the name of that Academy,—when the University opened, at length, its public courses of high teaching, it sought to associate in that object the most eminent scientific men of France,—and M. Gay-Lussac, though very young, recommended himself to it by the double title of chemist and natural philosopher. M. Gay-Lussac was already famous by his discovery of the fundamental laws of the expansion of gas and vapors,—by a balloon ascent, the most important and almost the only one of which the history of science has any record to keep,—and for many works on chemistry which tended to lay the basis on which that science was soon afterwards to be established."—M. Gay-Lussac was a Peer of France.

19. M. P. Souyet, an eminent chemist, died lately at Brussels at the early age of thirty-two. M. Souyet was Professor of Chemistry at the *Musée de l'Industrie* and at the Royal Veterinary School at Brussels. His funeral, on the 6th of May, was attended by the most eminent scientific men in Brussels; and M. Quetelet delivered an address, in which he briefly enumerated the important discoveries and chemical investigations that have rendered the name of M. Souyet so well known. M. Souyet had written several valuable chemical works.

20. M. Ducrotay de Blainville died in May, in his seventy-third year. He was found dead in a railway carriage upon the Rouen road on his way to England. He was the successor of Cuvier in the chair of Comparative Anatomy at the Museum of Natural History in Paris. He maintained his activity in science to the very last.

21. M. Kunth, a distinguished Botanist, Professor of the University of Berlin, died at Berlin, March 22, 1850.

22. Dr. Prout, the author of the Bridgewater treatise on digestion, &c., died in London about the middle of April.

V. Bibliography.

1. *A System of Mineralogy, comprising the most recent discoveries; including full descriptions of Species and their Localities, Chemical Analyses and Formulas, Tables for the Determination of Minerals, and a Treatise on Mathematical Crystallography and the Drawing of Figures of Crystals;* 712 pp. 8vo, illustrated by numerous wood cuts and four copper plates; by James D. Dana, A.M., etc. Third edition, rewritten, rearranged, and enlarged. New York and London: published by George P. Putnam, 1850.—In noticing this work we cite the Author's Preface, in which the changes the Treatise has undergone are mentioned, and the various contributions received from different sources are acknowledged.

"This Treatise, in the present edition, has undergone so various and extensive alterations, that few of its original features will be recognized. The science of Mineralogy has made rapid progress in the six past years; chemistry has opened to us a better knowledge of the nature and relations of compounds; and philosophy has thrown new light on the principles of classification. To change is always seeming fickleness. But not to change with the advance of science, is worse; it is persistence in error: and, therefore, notwithstanding the former adoption of what has been called the 'Natural History System,' and the pledge to its support given by the author, in supplying it with a Latin Nomenclature, the whole system, its classes, orders, genera, and Latin names, have been rejected; and even the trace of it, which the synonymy might perhaps rightly bear, has been discarded. The system has subserved its purpose in giving precision to the science, and displaying many of the natural groupings which chemistry was slow to recognize. But there are errors in its very foundation which make it false to nature in its most essential points: and in view of the character of these errors, we are willing it should be considered a relic of the past.*

Yet science is far from being ready with an acceptable substitute. Most *chemical* systems have been more artificial than the 'Natural' system; and doubts now hang over some of the principles of chemistry that are widest in their influence on classification. In view of the difficulties on either side, it was a point long questioned, whether to venture upon a classification that might be deemed most accordant with truth among the many doubts that surround the subject; or to adopt one less strict to science, that might subserve the convenience of the student for easy reference, and for the study of Mineralogy in its economical bearings, while at the same time it should exhibit many natural relations, and inculcate no false affiliations or distinctions of species. The latter alternative has been adopted:—the classification is offered simply as a convenient arrangement, and not as an exhibition of the true affini-

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* In the course of the volume the following paragraphs occur exhibiting the relation of Mineralogy to the other Natural Sciences, and the author's reasons for rejecting the system followed in his former editions.

"The whole range of inorganic substances, whether made by art or existing in the earth, constitute the Inorganic Kingdom. Minerals, as the term is used, are those species of this vast kingdom, that occur ready-made in the earth's crust. They exist by no different forces from the compound that proceeds from the laboratory; for it matters not whether sulphuric acid and lime come together in the workshop of art or nature; whether the hand of man bring the materials into juxtaposition, a running brook, an exhaling spring, or a volcanic fumarole: the result in both cases is gypsum, identical in chemical, physical, and crystallographic characters. The Science of Mineralogy hence, treats of only a small part of the third kingdom of nature. It includes here and there a species from the system—that is, those species that happen to have been formed by out-door processes. The limits of the department are not based on any grand points of difference between these and other inorganic compounds; they are assumed, in order to present together a collection of facts, which the student conveniently considers in one connection—facts relating to the natural productions of our globe.—p. 18.

In the classification of minerals it must be fully understood that we are dealing with but a small part of the third department of nature—the Inorganic Kingdom. The term Mineral Kingdom, so often used, is fundamentally erroneous, although all natural products not organic may be embraced under it. The distinction between *natural* and *artificial* inorganic products is convenient for the student, but is contrary to strict science; for nothing authorizes the wide separation usually admitted but the necessities of the school-room, or the fact that mineral information is the A B C of another science, and the basis of certain arts. Any classification therefore that can claim to be perfect, must take into consideration the whole range of inorganic compounds; and each species should have its place fixed on the broadest principles of the science of inorganic nature. A thorough knowledge of chemistry is required ties of species in the highest sense of the term. Among the silicates, however, it will be perceived that the groupings in the main are natural groupings; and throughout the work, special care has been taken to inculcate, as far as possible, the true relations of species, both by remarks, and by an exhibition of them in tables.

The system of classification which has been set aside for the arrangement adopted, is presented in a tabular form in the latter part of the volume. It is recommended as the preferable plan for arranging a cabinet, since it groups together species that are fundamentally alike —that is, alike in chemical and crystallographic characters—and prominently exhibits the various cases of isomorphism and polymorphism among minerals.

Special effort has been used to give completeness to the chemical descriptions of species, while at the same time, crystallography has not been neglected. In the latter department, a Mathematical chapter has been added, after Naumann's system—the system generally adopted in Germany, and recommended by its simplicity; and a second on the Drawing of Figures of Crystals. On the other side, the number of chemical analyses introduced has been increased fourfold, so that the student will have before him, a full registry, in most cases, of all mineral analyses hitherto made that are worthy of confidence. Chemical formulas have been given, and also the various opinions of different authors, where the constitution of a species is still in doubt. The most recent investigations in foreign Works and Journals, as far as they have reached this country, have been examined, and the Treatise is therefore posted up to the hour of its leaving the press. About one hund-

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to appreciate such an arrangement, and the fullest development of the science to give it perfection.

This view lowers mineralogy from its usual rank along side of botany and zoology. It exhibits, however, the true character and standing of the science, and enables us to appreciate its real objects and scope, and the basis upon which a classification should rest.—p. 170.

A systematic nomenclature like that for botany and zoology, is out of place in this science, for reasons already stated, except it be based upon relations among the whole range of inorganic products. The author here departs widely from principles deemed important in former editions of this treatise. The arrangement of Mohs, followed in the main heretofore, has not for some time been esteemed by him satisfactory, and it has been more and more obvious, with every passing year, that it could not stand the test of the developments of science. Even on its assumed ground of being a *natural* system, it is in many parts singularly artificial; and now that prejudices of early instruction have lessened, it seems little better in some of its groupings that an ancient classification of plants which arranged the hard wood species in one group, the herbaceous in another, or collected together flowers of a color. For it is on no better ground that the diamond is placed along side of topaz and sapphire; spathic iron near heavy spar, (instead of near calcite); graphite near psilomelane; allophane with green malachite; mica in the same order with cronstedtite, spodumene with prehnite; iolite with quartz and chrysolite: and so on. Some of these incongruities, the author in adopting the arrangement, had thrown out; but others remained, and were inseparable from the system. Yet in justice to this Mineralogist of merited celebrity, it should be said, that very many natural groupings were embraced in his classification—far more, indeed, than in many of the recent *chemical* systems; for the latter refusing almost all reference to physical characters, and considering only the elements present, instead of the mutual relations of the constituent elements, have broken up species into fragments and strewed them about into most heterogeneous assemblages."—p. 171.

red new species have been added to the science since the appearance of the preceding edition.

In the department of American Mineralogy, no pains have been spared to render the Work as complete as the nature of the case admitted. The Author would here gratefully acknowledge the valuable assistance he has received from various sources. He would especially mention his indebtedness to Dr. C. T. Jackson, for information upon the minerals of the Michigan Copper region, with Analyses of Telluric Bismuth of Virginia, and Chrysocolla, Apophyllite, and Analcime of Michigan, besides a description of Vermiculite, and an Analysis of this species in his laboratory by R. Crossley; also to Mr. Crossley, for an Analysis of Algerite and Schorlomite;—to J. E. Teschemacher of Boston, for observations on many species, including the Crystallized Black Copper ore and a Vanadate from the Lake Superior region;—to A. A. Hayes of Boston, for the blowpipe characters of Pyrrhite, and facts relating to Red Zinc Ore, and some other minerals;—to M. Adolph Schlieper, now of Lowell, Mass., for an Analysis of a Volcanic Labradorite, and the Cummington Manganese Spar;—to J. C. Booth of Philadelphia, for Analyses carried on in his laboratory of Emerylite, Euphyllite, Marmolite, an Iridescent Pyrites, a supposed Allanite, and other investigations, performed by T. H. Garrett, J. D. Darrack, and Ch. Hartshorne;—to Wm. S. Vaux and T. F. Seal of Philadelphia, and L. White Williams of Westchester, Pa., for much important information on the localities and minerals of Pennsylvania and Delaware;—to H. Wurtz of New York for Analyses of Brucite, and Nemalite, besides a new species he has named Melanolite;—to Hon. T. L. Clingman of North Carolina, for a catalogue of the North Carolina minerals;—to D. D. Owen and J. G. Norwood for an account of the minerals of Wisconsin, and other parts of the West;—to B. Silliman, Jr., for Analyses of Emerylite, and other species, and for aid in the optical examination of the American Micas, besides help of various kinds in the progress of the Work;—to H. Erni, assistant chemist in the Yale Laboratory, for Analyses of Danburite, Euphyllite, and a Feldspar;—to W. J. Craw of the same laboratory, for Analyses of Emerylite, W. H. Brewer, for Analyses of Hudsonite, and a Mica, (Margarodite), G. J. Brush, for Analyses of Williamsite, Deweylite and an Opal, J. B. Bunce, for an Analysis of Wollastonite;—to T. S. Hunt, for a catalogue of the mineral localities of Canada, and a description of the new species, Nickel Vitriol;—to Dr. F. B. Hough, for a catalogue of the localities of Northern New York, and a notice of the Capillary Pyrites of Antwerp;—to O P. Hubbard, for facts relating to the minerals of New Hampshire.

With so many Collaborators, the Work must bear some evidence of progress in American Mineralogy. The persons here mentioned are independent of those whose publications have appeared during the past six years—among whom we cannot properly leave unnoticed the names of C. U. Shepard, J. D. Whitney, Wolcott Gibbs, B. Silliman, Jr., T. S. Hunt, J. E. Teschemacher, F. Alger, L. C. Beck,—and W. Fisher, J. S. Kendall, and G. J. Dickinson of Prof. Booth's Laboratory, whose labors among American Minerals will be found reported under the species Schorlomite, Brookite, Ozarkite, Zircon, Gibbsite, Allophane, Boltonite, Unionite, Albite, Kyanite, Nuttalite, Serpentine, Algerite, Sodalite, Davyne, Brucite, Tetradymite, Garnet, Vivianite, Chondrodite, Pectolite, Wollastonite, Coracite or Pitchblende, Azorite, Chromic Iron, Black Copper, Pyroxene, Hornblende, Chladnite, and Shepardite.* If we cannot number many new species, we may claim that our knowledge in numerous cases has been rendered more precise. Some species of uncertain titles have been restored to credit, while others have been stripped of their seeming claims.

Among foreign laborers on American species, we should make honorable mention of M. Hermann, who has analyzed the Manganese spar of Stirling and Cummington, Gibbsite, Jeffersonite, Columbite, Pennite, and the so-called Troostite;—also of Prof. H. Rose, whose labors on Columbite are well known;—also of Rammelsberg, Delesse, Marignac, Damour, and Kerndt, to whom the Science is indebted for analyses or descriptions of American Bismutite, Brookite (Arkansite), Schorlomite, Washingtonite, Chrysoberyl, and Wolfram.

In the preparation of this edition, and especially the elaboration of its Chemical part, the Author has availed himself freely of the Chemical Mineralogy—'Handwörterbuch des Chemischen Theils der Mineralogie'—of Rammelsberg, and its biennial Supplements, in which all that is published respecting the composition of minerals is posted up with a fullness, discrimination, and erudition that leaves little for another hand. The tables of Analyses are, to a great extent, only another arrangement of the very valuable Work of this distinguished Chemist and Mineralogist. The various Foreign Scientific Periodicals and Transactions have also been consulted, both of Britain, France, Germany, and Russia, and every care has been taken to insure correctness and accuracy. Many facts of very recent date, that were received through new publications, or as private communications from different contributors to the Work, subsequent to the printing of the earlier part of the volume, are contained in an Appendix; and the reader will find it of use to him to add to the descriptions of species in the body of the volume, the number of the page in the Appendix where the mineral is again treated of.

The introduction of a table of atomic weights places it in the power of any, who will take the little trouble needed to understand its use, to calculate the results of analyses and test or compare their formulas. To the young student this will be found a most instructive exercise: and the proficient in the Science will appreciate the benefit of having a table of the kind at hand, arranged for easy reference."

We add further, that the volume contains 80 pages more than the preceding edition. And as about 70 pages of that edition are omitted, including the chapter on Rocks, and that on Mineralogical Bibliography (excepting four pages devoted to a list of the Works and Journals referred to in the course of the treatise);—and moreover since the mode of stating the results of analyses has reduced two-thirds the space the same amount would occupy, while the whole number of analyses given is increased fourfold, the quantity of matter added to this edition and not contained in the former is over 225 pages. The various additions have been made without increasing the size of the volume, a result partly secured by the use of good and firm instead of thick paper.

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* The name of Dr. Boyé should have been included, who published in the Proceedings of the Philosophical Society of Philadelphia, ii, 190, May, 20, 1842, an analysis as follows of the Granular Albite of Westchester, Pa.; silica 67·72, alumina with a trace of iron 20·54, magnesia 0·84, lime 0·78, soda 10·65, potassa 0·16=100·19.

J. D. D.

2. *The Unity of the Human Races proved to be the Doctrine of Scripture, Reason and Science, with a Review of the present position and theory of Prof. Agassiz;* by the Rev. Thos. Smyth, D.D. New York: G. P. Putnam. pp. 404, 12mo.—This volume is understood to have grown immediately out of the discussion on the unity of the human races at the late meeting of the American Association for the Advancement of Science held at Charleston. On that occasion, Prof. Agassiz appeared as the advocate of original plurality in the distributive centers of our race, but distinctly avowed his belief in their *spiritual* unity.

Dr. Smyth advocated the scriptural doctrine as it is usually understood and maintained, and the present volume is an exposition of this view of the subject.

On this question so interesting alike as a zoological, ethnological and moral enquiry, every enquiring mind will form its own conclusions. It is a perfectly fair subject of research, and nothing but the most exclusive and proscriptive bigotry can object to its free discussion. It is also a question on which many earnest minds seek light. It is intimately connected with the whole history of our race and cannot be pursued without constantly acquiring new facts relative to the arts, literature and commerce of the ancient nations. The scripture doctrine as generally received on this subject is most explicit and full,—that men sincerely desirous of knowing only the truth have found difficulty and doubt in investigating the subject, is a proof it is less simple than many have supposed. Dr. Smyth's book will be read with lively interest by all who are interested in candid discussion, and we wait with eagerness the arguments which his celebrated antagonist will bring to meet the conclusions of the present work.

3. *Report of Prof.* Alexander D. Bache, *Superintendent of the (U. S.) Coast Survey, showing the progress of that work for the year ending October*, 1849. 31st Congress, 1st Session. Ex. Doc. No. 4. 8vo, pp. 98, with 16 maps and sketches.—This report like its predecessors from the same source, gives ample evidence of the zeal, progress, and the highest scientific attainment in the prosecution of the great task of carrying out and completing the survey of the coasts of the United States. The report contains:—1. A general statement of the progress of the coast survey, and of the publication of its results. 2. A separate summary of the progress during the past year. 3. The work proposed for the next *fiscal year*, with the estimated cost. 4. A more detailed account of the several operations in each section of the survey, under the different officers, with a notice of the results obtained. 5. An account of the office work for the year. An Appendix contains tables of occupation of the parties and results, reports from the assistants on matters of interest to navigation, lists of maps published, and the like. The general progress of the coast survey as summed up in this report, occupies several pages, arranged under the sections into which the work is divided. The great increase of our coast line con-

sequent on the acquisition of California, &c., has much increased the labor and time required in the ultimate completion of the entire work. Dr. Bache remarks that the operations of the survey are now generally understood; but it is not so generally known that the scientific parts of the work which give it its great value—its essential value—are not the expensive parts, but that those most eminently practical are those that are most costly.

Dr. Bache states that the whole coast of the United States is very remarkably well adapted for the application of the geodetic method of survey. The difficult parts of the coast are reduced to so small a space that it is scarcely worth considering, and it is remarkable how the constant tendency is to contract this to still smaller dimensions, and how a close examination develops unexpected facilities, diminishing the resources required in applying a method which is as flexible as it is exact.

The magnetic telegraph has given new precision to this kind of survey just in the point in which it was least strong, and has rendered the measurement of an arc of a parallel an operation of the same kind with the measurement of an arc of the meridian.

A sketch of the operations of the coast survey in this new means of physical research will be found in the Appendix to the present number of this Journal. For further and important details we refer to the report itself.

4. *An Elementary Course of Geology, Mineralogy and Physical Geography;* by DAVID T. ANSTED, M.A., F.R.S., &c. London: J. Van Voorst, Paternoster Row. 1850. pp. 584, 12mo.—Prof. Ansted established his position as a successful scientific author in his scholarlike "Geology, Introductory, Descriptive and Practical," 2 vols., 8vo, published in 1844. The "Ancient World" of the same author, has also contributed largely to his reputation, and both those works have prepared the way for the present manual. It is what its title indicates, an *Elementary* treatise on the several subjects embraced in its range.

The order pursued is first, PHYSICAL GEOGRAPHY, in which are discussed the properties, conditions and forces of matter, the form, density and temperature of the earth, the distribution of land and water, rivers, lakes and mountains, plains, savannahs and deserts: the atmosphere and ocean with all the physical phenomena appropriate to them—changes in the earth's surface by the operation of temperature, winds and currents, or by organic agency—coral reefs, deltas, and distribution of marine animals. This department is closed by a chapter on the reaction of the interior of the earth on its external surface, under which head of course are grouped all the physical facts due to internal heat, geysers, mineral and hot springs, earthquakes and volcanoes with their geographical distribution.

The second chapter is devoted to MINERALOGY which is considered chiefly as the alphabet of geology and the exposition of products from the great laboratory of nature. The author has contrived to condense a great amount of information into this chapter in a tabular form, including numerous analyses, and he has added also brief descriptions of the most important minerals. At the close of this chapter a full index is appended containing about 1150 names of minerals, with references to the page where mentioned.

The third part of this work is devoted to DESCRIPTIVE GEOLOGY in which the nature, mode of aggregation and metamorphoses of rocks are dwelt on, their structure and mechanical displacement described, their classification through the distribution of organic remains is explained, and the value of fossils in determining relative age. After this follow chapters on the several great formations with their characteristic fossils.

Part fourth is occupied by PRACTICAL GEOLOGY exhibiting the application of geology to agriculture, to engineering, and to architecture. The final chapter is devoted rather fully to mining operations, and their reference to geological structure.

Not the least interesting portion of the volume to those engaged in scientific instruction, is the Appendix, containing in detail the schedules for examination of students in geology and mineralogy at Kings College in London, from June, 1840, to September, 1849. A judicious glossary of terms employed closes this useful work.

It is so seldom that we find a work of any kind, and particularly a scientific work, which has either an index or table of contents of any value, that when one like the present does present itself, so fully equipped for usefulness in this respect, we cannot pass it without a word of commendation and approval. Next to having the inherent qualities of excellence in a book do we value these indispensable aids in reference, without which the labors of an author deserve the oblivion which we are persuaded they often meet, from the neglect of a duty which is none the less important because it is irksome and repulsive.

We look for an early American edition of Prof. Ansted's work.

5. *The Natural History of the British Entomostraca;* by W. BAIRD, M.D., F.L.S., etc. London, 1850. 364 pp., 8vo, with 36 lithographic plates, partly colored. Published by the Ray Society.—Dr. Baird has very thoroughly investigated the Entomostraca of Britain, and able articles from him have from time to time appeared during some past years in different English publications.* The present volume embodies all his former researches, with many others recently made, and embraces full descriptions with the synonymy of all British species known, and observations on the general characters and habits of these minute Crustacea. The species are illustrated with figures, which in many cases are given with minute details of structure. The publication of works of such merit by the Ray Society commends this association to all interested in the progress of science.

6. *Index Palæontologicus, oder übersicht der bis jetzt bekannten Fossilen Organismen,* unter Mitwirkung der HH. Prof. H. R. GÖPPERT und HERM. VON MEYER, bearbeitet von Dr. H. G. BRONN. Part I, *Nomenclator Palæontologicus,* alphabetically arranged, lxxxiv and 1384 pp. 8vo; Part II, *Enumerator Palæontologicus,* or a systematic grouping of fossils, exhibiting their positions in the rock series, and their relations to the successive geological epochs, 980 pp. 8vo.—This new Palæontological work by Dr. Bronn, and his learned coadjutors,

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* The Magazine of Zoology and Botany, i, 35, 310, 514, ii, 132, 400; Annals and Magazine of Natural History, (continuation of the preceding,) i, 245, xi, 81, xvii, 410, and 2nd series, i, 21, 396;—Also Trans. Berwickshire Nat. Club; Dieffenbach's New Zealand.

Göppert and Meyer, exhibits in every part the most laborious research, great skill in arrangement, and a wide comprehension of the bearing and relations of the various facts in the science. Part I, commences with some general remarks on the study of fossils. A Bibliography follows, extending over 36 pages, and half as many more are occupied with an explanation of the abbreviated references. Then begins the *Nomenclator*, which is an alphabetical list of all known genera and species of fossils, covering 1380 pages. The author of the name in each case is mentioned, the page of the work or Journal on which described, the plate and figure if figured, the rock formation to which the species belongs, often the country where it occurs, with occasional synonyms and important observations upon the family or class in zoology to which each genus pertains. The system of condensation is carried so far that, in general, all this information is embraced in a single line, or even less. It is obvious that a work of this kind carefully prepared is exceedingly valuable to such as are interested in the study of fossils. Dr. Bronn states that he was nine years in the preparation of the work, and in that time the number of described species was doubled.

Part II, or the *Enumerator Palæontologicus*, consists of tables exhibiting the geological distribution of species, both as regards the series of rocks (26 divisions in which are referred to, and still others subordinate) and also the continent and part of continent where found. The species are systematically distributed according to the natural orders or families. The relations of the different groups to the different geological epochs is thus exhibited to the eye. The great subject of the dependence of species on the circumstances under which they existed, or their accommodation in organization to these circumstances, is presented in a strong light, both in the tables and subsequent chapters. There are other tables and other subjects discussed with ability, for which we must refer to the work.

We understand that this valuable work may be had in this country of Mr. Garrigue and of Westermann, Brothers, in New York City, of Eggers and Co., Cincinnati, and of F. Schuster, in St Louis.

Prof. Bronn will soon be engaged upon a new edition of his Lethæa Geognostica, which work will be greatly enlarged.

7. *Elements of Scientific Agriculture, or the connection between Science and the Art of Practical Farming*, (Prize Essay of the New York State Agricultural Society,) by Prof. John P. Norton, M.A.: Albany, E. H. Pease & Co., 1850. pp. 208, 12mo.—"This little treatise is an attempt to supply a great and growing want in our country; a want of some elementary work that shall clearly and distinctly explain the great principles that are involved in the application of science to agriculture." —(Preface.)

In the opinion of the Committee of the New York Agricultural Society, of the authorities of the State and of the leading teachers, this want in agricultural literature is here supplied in a manner the most complete and satisfactory. They have awarded to it the prize of one hundred dollars, offered for the best treatise of this nature, and it goes out with all the prospect of great and general usefulness which can be hoped for from the high recommendations of its judges, and the reputation of its meritorious author. Nothing more is wanting to satisfy the clamor of those who doubt the possibility of any good practice coming from books, than such examples as the present, of the union of accurate practical and scientific knowledge in the same volume, set forth in intelligible but untechnical terms, and rich in illustrations drawn from the researches of the laboratory. Few we think are so enthusiastic as to believe that 'Chemistry made easy' will ever teach our farmers the art of chemical analysis; but the day is at hand when it will be no longer safe or reputable for those who cultivate the soil, to be ignorant of the elements of those sciences on which successful practice depends. Such books as the present widely distributed and perused are the surest means of disseminating and fixing these fundamental truths in the practitioners of the "mother of arts."

8. *A Treatise on Algebra, for the use of Schools and Colleges;* by S. Chase, Prof. Math. Dartmouth College. 336 pp. 12mo. New York, 1849; D. Appleton & Co.—This text-book for the study of Algebra is convenient in size, clear, concise and rigorous in style, and well fitted for instruction. The author states that he has brought out prominently the expressions and formulas required in the higher applications of algebra, in order to render them familiar and easy of use. The work is therefore well adapted to carry the student forward in his mathematical course and prepare him for the reasonings and investigations of Trigonometry, Analytical Geometry, mechanics, and other branches of mathematical study. The convenience of the student is still further promoted by a tabular view of the principal algebraic formulæ.

9. *Minerals and their uses, in a Series of Letters to a Lady;* by J. R. Jackson, F.R.S., London. 1849. 12mo, pp. 464. Jno. Parker. —As its title implies, this is a work designed especially for the ladies. The author has with considerable skill and some small talk grouped under the several species such facts as are most interesting to the lady reader.

10. *Third Annual Report of the Regents of the University, of the Condition of the State Cabinet of Natural History and the Historical and Antiquarian Collection annexed thereto,* (made to the Senate of the State of New York, January 11, 1850,) Albany, 1850. 176 pp. 8vo, with numerous plates.—This Report consists of a Catalogue of the specimens in the different departments of Natural History, and that of Indian Antiquities, added to the collections from Jan. 1, 1849, to Jan. 1, 1850. Many of the various Indian curiosities, some of which are of singular interest, are figured and described, and they are followed by a notice of several ancient remains of art in Jefferson and St. Lawrence counties, by F. B. Hough, M.D., illustrated by sketches.

Under the Mineralogical Report, by L. C. Beck, M.D., additional information is given with regard to the minerals and mineral springs of the state, partly from other publications, and partly from original observation. A mineral resembling hypersthene from Orange county, N. Y., afforded Beck on analysis, silica 59·50, oxyd of iron 12·00, magnesia 27·75. This composition, if we take the iron in the mineral as protoxyd, gives for the oxygen of the protoxyds and silica 13·32 : 30·92, which is very near 4 : 9, the ratio in hornblende, whence the formula $(\dot{M}g, \dot{F}e)^4\dddot{S}i^3$.* A greenish compact asbestus (rockwood) from Staten

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* See Dana's Mineralogy, 1850, p. 685.

Island, gave Silica 55·20, magnesia 30·73, oxyd of iron 11·82, water 2·25=100. Taking the iron as protoxyd in the mineral, the analysis gives for the oxygen of the protoxyds and silica 14·44 : 28·68, or 1 : 2, the ratio in pyroxene, and leading to the formula $(\dot{M}g, \dot{F}e)_3 \overline{S}i_2$.*

Following the Mineralogical Report there is a catalogue of plants; and then an account of some new species of fossils, and observations on others, by James Hall, with lithographic illustrations. The species remarked upon are named Buthotrephis cæspitosa, Retepora [?] fenestrata, Ægilops (new genus) subcarinata, Murchisonia subfusiformis, Subulites abbreviata, Oncoceras constrictum, Ormoceras remotiseptum, Endoceras lativentrum, Colpoceras virgatum, and Asaphus extans.

11. *Zoology of the Voyage of H. M. S. Samarang under the Command of Capt. Sir Edward Belcher, during the years* 1843–1846. *Crustacea*, parts I and II; by ARTHUR ADAMS, F.L.S., and ADAM WHITE, F.L.S., 66 pp. 4to, with 13 plates.—The numerous species described and figured in this very important work belong almost exclusively to the order Decapoda. The authors have proposed several new genera, brief notices of which have been before published by them in the Proceedings of the Zoological Society of London. The number of new species here proposed is seventy-nine. The plates are excellent and in part colored.

12. *Hunt's Merchant's Magazine and Commercial Review;* conducted by FREEMAN HUNT. In monthly numbers of 128 pp., 8vo, New York. —This monthly is one of the Scientific Journals of the country, although the title may not indicate it, and sustains a high character. Its articles are elaborate, and embrace the subjects of Commerce, the Arts and Manufactures, Mercantile law, Insurance, Currency, and related topics: and in each volume a fund of information is collected together, in which every member of society is interested, that cannot be elsewhere obtained in so convenient or full a manner.

13. *Astronomical Journal, Cambridge*, No. 7, APRIL 20, 1850. Observations of Astræa; made with the Filar-micrometer of the Washington Equatorial; *James Ferguson.*—On the recent telegraph operations of the U. S. Coast Survey; *Sears C. Walker.*—Note from *J. S. Hubbard* on *Encke's* comet.—No. 8, MAY 7. On the orbit of the great comet of 1843; *J. S. Hubbard.*—On an error in the Greenwich planetary reductions; *Ernst Schubert.*—On the Longitude of Hudson (Ohio) Observatory; *Elias Loomis.*—No. 9, MAY 27th. On the Longitude of Hudson (Ohio) Observatory; *Elias Loomis.*—On a machine for the mechanical calculation of occultations; *Rev. Thos. Hill.*—Elements of Iris; *Ernst Schubert.*—Note on the Longitude and Latitude of Washington, D. C.; *James Carley.*—Supplementary note on an error in the Greenwich planetary reductions; *Ernst Schubert.*—Ephemeris of Neptune; *S. C. Walker.* —Lamont's observations of Neptune.—Comet of May 1st, 1850.—No. 10, JUNE 10th. Ephemeris of Neptune, 1850; *S. C. Walker.*—Observations of Astræa and Hygea; *James Ferguson.* From letters of Prof. Schumacher, to the editor.—Observations of Petersen's comet made at the Cambridge Observatory; *W. C. Bond.*—Southern comet of November, 1849. Letter from Prof. Maury to the editor, with Fer-

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* Dana's Mineralogy, 1850, p. 692.

guson's further observations on Petersen's comet.—On the fifth comet of 1847; *B. A. Gould, Jr.*

14. *Scientific Annual.*—A second edition of this volume with some emendations and additions has been prepared and issued. It is gratifying to know that the work has met with so large a sale, and will be continued in future years.

15. *Iconographic Encyclopædia;* by G. HECK, translated by Prof. S. F. BAIRD,—published by R. Garrigue, New York.—Part 9 of this work has just appeared, containing geographical plates Nos. 23 to 42, and text, pages 641–649 vol. i, and vol. ii, pages 1 to 80.

LT. M. F. MAURY: Notice to Mariners; (second edition,) being sailing directions for the new route to Rio, with tabular comparisons of voyages by the old and new routes. *Washington,* 1850.

DR. BENJAMIN APTHORP GOULD, Jr.: Report to the Smithsonian Institution on the history of the discovery of Neptune. 8vo, pp. 56. Published by the Smithsonian Institution.

JAMES HIGGINS, M.D.: Report as State Agricultural Chemist, to the House of Delegates of Maryland. *Annapolis.* 1850. pp. 90.

LOVELL REEVE: Conchologia Iconica, or figures and descriptions of the shells of molluscous animals. 4to, parts 1–85, also in separate monographs. *London.* 1850.

—— ——: Conchologia Systematica; or a complete System of Genera, illustrated with 300 plates and over 1500 figures of species. 2 vols. 4to. *London.* Colored 10*l.*, plain 6*l.*

—— ——: Elements of Conchology, an introduction to the natural history of shells—parts i to x. 3*s.* 6*d.* each.

—— ——: The Conchologist's Nomenclator: or Catalogue of recent species of Shells, &c. 21*s.*

—— ——: associated with Arthur Adams, F.L.S. Mollusca of the Voyage of H. M. S. Samarang. Part II, published May 1.

ROBERT HUNT: Panthea, the Spirit of Nature. 8vo. *London.* 1850.

—— ——: Poetry of Science (second edition): or Studies of the Physical Phenomena of Nature. 8vo. *London.* 1849.

Rev. DAVID LANDSBOROUGH: Popular History of British Sea-weeds. 16mo. *London.* 20 colored plates. 10*s.* 6*d.*

JOHN RALFS: The British Desmidieæ; or fresh water Algæ. 1 vol. royal octavo. 35 plates, colored. 36*s.*

REICHENBACH: Researches on Magnetism and the other imponderables in their effects on the living frame. Translated and edited by Dr. Gregory. 1 vol. 8vo. *London,* May, 1850.

ARTHUR HENFREY: Reports and Papers on Botany, 514 pp. 8vo, with 8 plates; published by the RAY SOCIETY, London, 1849.—This volume contains, 1, MOHL on the Structure of the Palm-Stem; 2, NÄGELI on Vegetable Cells; 3, NÄGELI on the utricular structure in the contents of cells; 4, LINK's Report on Physiological Botany for 1844-45; 5, GRISEBACH's Report on Geographical Botany for 1844; 6, GRISEBACH's Report on Geographical and Systematic Botany for 1845.

PROCEEDINGS OF THE ACAD. NAT. SCI., PHILADELPHIA, vol. v. No. II. March, April, 1850.—p. 22. Catalogue of Crustacea in the Cabinet of the Academy, with critical notes, by *Prof. L. R. Gibbes,* and a committee of the Society, (whole number of genera in the collection, seventy-eight, and of species, one hundred and seventy-five.)—p. 30. Continuation, on the size of the brain in man; *S. G. Morton.*—p. 32. Observation on crystalline bodies in animal tissues; *J. Leidy.*—p. 34. On new American species of Annelida abranchiata; *J. Leidy,* (article to be published in the Journal of the Academy.)—p. 35. Descriptions of new Entophyta growing within animals; *J. Leidy.*

PROCEEDINGS OF THE BOSTON SOC. NAT. HISTORY. November and December, 1849.—p. 193. New shells from Africa (Vaginulus 1 species, Succinea 2, Helix 8, Bulimus 2, Achatina 3, Amnicola 1, Ampullaria 1, Trichotropis 1, Aplysia 1); *A. A. Gould.*—p. 199. Observation on Lepidoptera; *Agassiz.*—p. 200. On the probable origin of certain fossil rain drops; *Whitney* and *Desor.*—p. 203. Observations on the foot of a species of Moschus; *J. Wyman.*—On the circulation and digestion in the lower animals; *Agassiz.*—p. 206. On the Land dunes of Lake Superior; *Desor.* May, 1850, pages 209–224.—On a young Mastodon; *J. Warren.*—Point of resemblance between Mastodon and Manatee; *L. Agassiz.*—Survey of government Lands on Lake Superior; *J. D. Whitney.*—Skulls of four Hindoo Castes; *Dr. Kneeland.*—Shells of U. S. Exploring Expedition; *A. A. Gould.* Books received ending Dec. 31. Calamite, of Bridgewater, Salt of Great Salt Lake and Carbonate of Soda from "Saleratus Lake;" *C. T. Jackson.* Tin in graphite slates of Vermont; *C. T. Jackson.*

Annales des Sciences Naturelles. MAY, 1849. Researches on Coral Zoophytes, continuation of the very elaborate memoir of *Milne Edwards* and *J. Haime.*—Organization and development of the Linguatulæ, and description of a new species; *P. J. Van Beneden.*—Report on a memoir by Dr. Weddell, on the Natural History of the Quinquinas; *A. de Jussieu.*—Rectification of the Review of the genus Cinchona, published in vol. x, p. 5; *A. Weddell.*—17th notice of the Cryptogamous plants recently discovered in France; *J. B. H. J. Desmazières.*—Chronological exposition of the periods of vegetation, and of the different Floras which have existed successively on the earth's surface; *Ad. Brongniart.*—JUNE. On the Linguatulæ, continued; *Van Beneden.*—On the formation and structure of muscular fibre; *Dr. Lebert.*—Periods of vegetation and floras of the earth, continued; *Ad. Brongniart.*—17th notice of the Cryptogamia of France, continued; *Desmazières.*—New researches into the anatomy and physiology of the Fig tree and Caprificus; *G. Gasparrini.*—Growth of the embryo of Phanerogamia, a series of microscopic researches; *W. Hofmeister.*—JULY. New observations on the Diatomaceæ; *G. H. K. Thwaites.*—On vegetable Embryogeny; *L. R. Tulasne.*—On the organization of the Helminthidæ; *E. Blanchard.*—AUGUST. On vegetable Embryogeny, continued; *L. R. Tulasne.*—On Annelida, continued; *E. Blanchard.*—On the Osteology of the fish called Triodon macroptera; *C. Dareste.*—On a new genus of Brachiopoda, (Davidsonia,) forming a connecting link between the articulated and non-articulated species; *M. Bouchard-Chanteraux.*—Researches on Coral Zoophytes; *M. Edwards and J. Haime.*

Archiv für Naturgeschichte, W. F. Erichson.—*Berlin.*—No. III, 1848. On the Egg of Snails, continued; *H. Rathke.*—On the Echinorhynchus Tuba; *Dr. Creplin.*—Description of a new species of Ascaris, found in the Python bivittatus; *A. Retzius.*—Anatomy and Natural History of Angiostoma limacis; *Dr. Fr. Will.*—Description of small species of Mammalia from Syria and Africa, Genera Rhinolophus, Myoxus, Meriones, Hypudæus, Mus; *A. Wagner.*—On the Gregarinæ; *A. von Frantzius.*—Continuation of the Report on Insects, Arachnida and Crustacea for the year 1847; *Erichson,* (unfinished in consequence of the death of Erichson, and to be completed with the Report for 1848).—Report on Mammalia for 1847; *A. Wagner* of Munich.—No. IV. On the Gregarinæ, continued; *A. von Frantzius.*—Ornithological Fauna of the Faroe Islands, from Kröyer's Tidsskrift; *P. Alberg Holm.*—Report on Mammalia for 1847; *A. Wagner.*—Report on systematic Botany for 1846; *A. Grisebach.*

No. I, 1849. Edited by Dr. F. H. Troschel, Professor at the Friederich-Wilhelms-Universität at Bonn, in connection with Prof. Dr. Grisebach of Göttingen, Prof. Dr. Siebold of Freiburg, Prof. A. Wagner of Munich, and Dr. Leuckart of Göttingen.—15th year. Part I. 1849.—On Boring Mollusca; *A. Hancock.* (From Mag. Nat. Hist., ii, 225, 1848). On the propagation of the Kangaroo; *Dr. Leisering.*—On the bony structure of the Sea Bear and sea Otter; *A. Wagner.*—Third appendix to Gurlt's memoir on the Endozoa of animals; *Dr. Creplin.*—On the anatomy of the Ornithorhynchus and Tachyglossus; *Prof. Mayer* of Bonn.—On the development of Infusoria; *Dr. F. Stein.*—No. II. Development of Infusoria, continued; *Dr. F. Stein.*—Fauna of Iceland, (1st part, Worms); *Dr. R. Leuckart.*—On the shells of the Muscle and Pearls, and their crystallographic and mineralogical relations to calc spar and arragonite; *J. Nöggerath.*—On the mouth parts of the Helicinæ; *Dr. Troschel.*—A word on the quinary System; *J. Kaup.*—On the Boring Mollusca, (continued); *A. Hancock.*—Report on Mammalia for 1848; *A. Wagner.*

Journal of the Indian Archipelago and Eastern Asia, vol. viii, No. i, 1849.—p. 65. A contribution to the knowledge of the Ichthyological Fauna of Celebes, by Dr. Bleeker. [Contains a catalogue of species, and description of several that are new.]

Soon to appear, published by Gould, Kendall and Lincoln, of Boston, *Hugh Miller's* Footprints of the Creator, with a memoir of the author, by Prof. Agassiz, and also, *Hunt's* Poetry of Science, both works of great merit and interest.

APPENDIX.

Report on the Experience of the Coast Survey in regard to Telegraph Operations, for determination of Longitude, &c.[*]

[Extracted from the Proceedings of the Am. Association for the Advancement of Science, 1849, p. 182.]

Mr. Sears C. Walker, Assistant in the United States Coast Survey, by instructions from the Superintendent, communicated the substance of his recent Report on the Experience of the Coast Survey, in regard to telegraph operations, as follows:—

The duty of communicating to the Association the experience of the United States Coast Survey, in regard to telegraph operations, has been assigned me by the Superintendent.

The first mention of the electro-magnetic telegraph, in connection with longitude operations, as far as I know, was made, in 1837, by M. Arago to Dr. Morse.

The first practical application of the method was by Captain Wilkes, in 1844, between Washington and Baltimore. Two chronometers, previously rated by astronomical observations in the vicinity, were brought to the two telegraph offices, and were compared together through the medium of the ear, without coincidence of beats. This process is accurate enough for geographical or nautical purposes; but its precision stops short of the mark where the requirements of geodesy begin. In fact, two clocks beating the same kind of time, when placed side by side, cannot be compared together, by the human ear, with sufficient precision for geodetical purposes. The subsequent experience of the

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[*] This article should have appeared in this Journal, at an earlier day; but the very tardy issuing of the volume of 'Proceedings,' &c., in which it is printed, prevented our publishing it at the same time with the article on the 'Electro-chronograph' by John Locke, which appeared in September last year, (vol. viii, p. 231.)

It is well known that a personal controversy exists among claimants in this interesting research. It is not our purpose to discuss its merits, did we understand them. The responsibility of published statements must rest with those who make them, and we wish it distinctly understood (as we suppose indeed it now is), that the Editors of this Journal hold themselves responsible for no facts or opinions published in these pages, unless uttered in their own individual or collective names. No articles find admission to our pages without the name of a responsible author, and beyond the strict limits of improper personality, the authors alone are to be held responsible for the ground assumed in their several communications.

A long experience has convinced us that there is no ground, except that announced above, on which we can safely stand, in cases where controversy exists in matters of science.—*Editors Am. Jour. Sci.*

Coast Survey has shown, that where several astronomers make independent comparisons of clocks, in this manner, two seconds of arc, or twelve-hundredths of a second of time, is an average discrepancy between their results.

The subject of telegraph operations for longitude had engaged the attention of the Superintendent of the Coast Survey, previous to the experiment of Captain Wilkes; but the orders received by me for this purpose, bear date of November 24, 1845. In 1846, the very first season in which two astronomical stations of the Survey were brought in connection by the Morse telegraph lines, the work of connecting them together, in longitude, was commenced in earnest by the Superintendent of the Coast Survey. The coöperation of the National Observatory, as one of the stations, was freely tendered by its Superintendent, Lieut. Matthew F. Maury, U. S. N., and accepted by Prof. Bache. The detail of the operations was left to me. The Comptrollers of the Public Schools of Philadelphia had tendered the free use of their High School Observatory, under the direction of Prof. E. Otis Kendall. An additional station, at Jersey City, was fitted up by the Coast Survey, with astronomical instruments, under the direction of Prof. E. Loomis. The three stations were connected by special junction lines, (built at the expense of the Survey,) with the main Morse line, from Washington to Jersey City, under the Presidency of the Hon. Amos Kendall. Three full sets of telegraph keys and receiving magnets were made for the purpose, at the machine shop of the Coast Survey Office, under Mr. Saxton's directions, and three Morse registers were purchased for the occasion, from Mr. Clark, an instrument-maker in Philadelphia.

Owing to the imperfect insulation of the lines, the connection of Jersey City with Washington failed that year; but the Washington and Philadelphia stations were connected together astronomically on the 10th and 22d of October.

The method of comparison, by coincidence of beats of solar and sidereal timekeepers, was not introduced this year; but the equivalent one was employed, namely, the exchange of star signals. These are the dates of instants of the passage of a star over the wires of the eye-piece of the transit instrument, signalized by tapping on the telegraph key at one station, and recording it on the Morse register at both.

Since this operation of making the time of a star's transit legible on any number of registers at any number of stations is likely to come into general use, in geodesy, geography, and hydrography, so long as there remains on the earth's surface any two important points whose relative longitude is unknown, the origin of the method must be a subject of historical interest.

The idea of substituting for clock signals, which have no immediate relation to longitudes, those of the times of a star's transits, which have such a relation, occurred in the winter of 1845 and 1846, in a consultation between the Superintendent and myself. Which made the first suggestion, I cannot now say, nor is it a matter of much importance to either of us personally. As respects the service in which we are engaged, the origin is a matter of importance. It is a subject of just pride to those engaged in it, that the first conception of the method, and the first practical operation with it, are peculiarly its own. The blank form, No. 2, of telegraph operations, drawn up by me in the spring of 1846, and lithographed for use at the three stations, is headed "Coast Survey," and is described in my lithographed "Circular to the Telegraph Operators." It is dated "Coast Survey Office, September 25th, 1846." In pursuance of this programme, on the 10th of October, the transit of the star 2838 Bailey, over the seven wires of the west transit instrument of the Washington Observatory, was signalized by Lieut. Almy, U. S. N., the officer having charge of that instrument. This transit was noted on the Washington clock, by Lieut. Almy, and also by myself, comparing together, by the ear, the seven key beats, with the clock beats. The same key beats were also noted by Prof. Kendall, at Philadelphia. This was the first practical application of the method of star signals, which is sooner or later to perfect the geography of the globe. The signals were made visible on the running fillet of paper. The fillet was not then furnished with a visible graduation.

The *personal graduated clock register*, and the *personal register of the star signal*, were both made in an evanescent form on the *auditory nerve* of the ear. Two years later, (1848,) the *visible* was substituted for the *auditory* register, in the month of July. In the month of November, the *automatic visible register* took the place of the *personal visible register*, and constituted the last step in the improvement of the art of telegraph operations for longitude.

Whether we use the *personal auditory*, *personal visible*, or the *automatic visible* register, the theory of the resulting longitudes is the same. They differ only in the superior facility, precision, and permanency of the latter.

This analytical theory, from beginning to end, belongs to the Coast Survey Service. My letter to the Superintendent, on file in the Coast Survey Office, dated October 3d, 1846, contains the *analytical theory* of longitudes by star signals, whether recorded on a *personal auditory register*, as in 1846, a *personal visible register*, as in 1848, or an *automatic visible register*, as in 1849.

I deem it, therefore, but a duty to the service in which I am engaged, to declare, in the presence of the members of the Association, that, with the single exception of the experiment between Baltimore and Washington, by Captain Wilkes, in 1844, I know of no telegraph operations for longitude, and of no step in the improvement, or perfectionment of the art in Europe or America, which have not been the work of the officers proper of the Coast Survey, or of commissioned officers and civilians acting temporarily as assistants.

After this digression, I resume the recital of our experience in the Coast Survey.

In 1846, we connected together, in longitude, the Washington and Philadelphia stations. In 1847, the programme left unfinished in 1846, by the imperfection of the lines, was resumed and completed, and Washington, Philadelphia, and Jersey City, were connected together. On the 27th of July, 1847, the method of coincidence of beats, used so successfully by R. T. Paine, Esq., in the chronometric operations for longitude, in Massachusetts, and by Struve and Airy in their chronometric enterprises, was applied to the telegraphic comparisons of the Philadelphia and Jersey City Clocks. This method of coincidences was used in combination with exchanges of star signals in the telegraphic operations of the Coast Survey, in 1848, when the Cambridge Observatory, under Prof. Bond, and the Stuyvesant station in the garden of Dr. Rutherford, New York, under the direction of Prof. Loomis, were connected together by the Coast Survey. The lines of junction with the main line, under the presidency of the Hon. Francis O. J. Smith, the telegraph apparatus, and the astronomical instruments of the Stuyvesant station, were furnished at the expense of the Survey. During these operations, in July and August, Prof. Bond proposed to substitute the *automatic* instead of the *personal seconds circuit breaker*, and submitted to me a sketch of his plan for effecting the *make* and *break* circuit by the escapement beat. On my special recommendation, by report to the Superintendent, dated August 11th, 1848, an order was given to Mr. Bond for the completion of a *circuit breaker clock* on his plan.

The *automatic clock circuit breaker*, named by Dr. Page, of Washington city, an *electrotome clock*, is not an American invention. It was used more than ten years ago, by Messrs. Wheatstone, Bain, and Steinheil, in Europe. It is due also to Prof. Bache, Mr. Saxton, and Dr. Morse, to say that each of them suggested the use of *clock electrotomes*, in 1846, with particular descriptions of the methods. I was deterred from using them in connection with the observing astronomical clocks at the time, from apprehension of disturbance of their rates.

This apprehension was in reality groundless, and I would here make the remark that all the methods then and since proposed or tried, for *clock electrotomes*, and all the various methods of registering, are precise enough for the purposes of geodesy. Hence, in giving preference to one over another, we should only be guided by considerations of facility and economy of outfit, and of facility of making, reading, and preserving the printed registers.

After concluding the work between Cambridge and New York, in 1848, the month of October was employed by the Coast Survey in connecting Philadelphia and Cincinnati, by means of the O'Reilly Morse lines. The Philadelphia junction line was made by the Coast Survey. The Cincinnati junction line of half a mile in length was erected by Henry O'Reilly, Esq., and presented to the Cincinnati Observatory, as his subscription towards that establishment. The transit and telegraph instruments for Cincinnati, were supplied by the Coast Survey for Prof. Mitchel.

The labors of the year 1848 comprise some 1800 observed transits of stars, 800 comparisons of chronometers, by coincidences of beats taken at the stations, 5,000 transits over wires, for determining the personal equations of the officers of the Survey, many thousand exchanges of personal clock signals, and 600 of star transit signals.

If even this prodigious accumulation of statistics was considered a gain of many fold over the old method of obtaining astronomical longitudes, what shall we say of the automatic process employed in 1849, where one night's exchange of star-signals between Philadelphia and the Seaton station, printed automatically on the single sheet of paper now before you, is worth the whole list of statistics collected by the Coast Survey between Philadelphia and Washington, in 1847.

The subject of the invention of the automatic clock register is explained in full in my Report to the Superintendent of the Coast Survey, of December 15th, 1848, which, with his letter communicating it to the Treasury Department, and that of the Hon. Robert J. Walker, communicating both to Congress, have since been extensively circulated by the press.

I will not here allude to the respective claims of Americans for priority or superior excellence of inventions and suggestions, believing that it will be becoming for all of us, to look to the great work that has been accomplished, by our united efforts, rather than to the single share of each.

Feeling the responsibility under which I was acting, I spoke with caution on the subject of the comparative excellence of the automatic printing method; though some of my friends thought that its merits were overrated. I appealed to the experiments that were to be made in the campaigns of 1849 for a test of the new method. That which was then anticipation only, is now reality; and I am able to say, from recent trials, between Cambridge and Washington in January last, and between the Seaton station under my care at Washington, and the stations at Philadelphia under Prof. Kendall, and Hudson, Ohio, under Professor Loomis, in July ~~and~~ the current month, that the excellence of the new method surpasses all that I ventured to hope for in December last. I then ventured to claim for the automatic printing method a ten-fold gain over the old one. I now find that one transit over one wire is worth four wires by the old method, and that ten transits over wires may now be printed, where one was done before; making a gain by the new or automatic method of some forty-fold. I mean by this the gain from multiplication of transits over wires, and superior precision of each. We cannot in one night obtain the advantage of the average of the meteorological peculiarities of forty.

The various clock *electrotomes* may be thus classified:

Author.	Date of invention or suggestion.	Description of method.
Wheatstone . . .	1840.	Circular disc on arbor of second's wheel.
Bain	"	Sliding rod moved by pendulum.
Steinheil	Not known.	
Saxton	At launch of Frigate Raritan.	Platinum tilt hammer moved by pendulum.
Saxton	In 1846.	Globule of quicksilver struck by pendulum.
Johnson & Speed .	In 1847.	Platinum tilt hammer struck by teeth of the minute wheel.
Bond	In 1848.	Escapement electrotome.
Mitchel	"	Quicksilver struck by pendulum.
Locke	"	Platinum tilt hammer struck by teeth of seconds-wheel.

I have already remarked that I believe that all these electrotomes will succeed in practice, without injury to the rate of the clock. In making our selection we must look to facility and cheapness of construction, and to uniformity of graduation of the time scale. In the present state of my experience on this subject, I prefer the form now in use at the Seaton station, recently applied by Mr. Saxton to the Hardy dead-beat clock of the United States Coast Survey, imported by its late Superintendent, Mr. Hassler, and by him described in the Transactions of the American Philosophical Society. The electrotome is on the model used by Mr. Saxton several years ago, at the time of the launch of the frigate Raritan, at Philadelphia. The perfect gravity escapement, (resembling, I believe, that which was recently invented by Dr. Locke,) has been substituted by Mr. Saxton for Hardy's springs. Two pounds have been added to the weight of the clock to prevent danger of stopping by increased friction. In this condition Mr. Saxton expresses the opinion that the clock of the Seaton station is the best clock extant. It has broken the circuit for forty days without interruption, and has in no instance deviated in an appreciable amount from its losing rate of one-tenth of a second per day. For a more full understanding of it, I refer you to the accompanying description and drawings by Mr. Saxton.

I have spoken of the *automatic circuit breaking clocks;* it remains to notice the *automatic registers.* The first in order is the registering fillet of Dr. Morse, described in my report of December last. This has no maintaining power. It may be made to run with one winding for fifteen minutes; but gives uncertain records during the time of winding.

In reading off the dates of the signal electrotomes on the clock electrotome scale, a small strip of paper or of horn, is used, which in ten inches diverges from a point to the extent of a second on the register. This is placed on the fillet of paper, so that its width equals the distance of the clock and signal electrotomes. The tenths of seconds are read off at sight, and hundredths are set down by estimation. A correction for rate of the actual time scale on that of the normal or measuring scale might be applied if we wished; but on experience of a month at the station, we find that the neglect of it brings an error not greater than that of the conjecture, relative to the hundredth of the second, so that in practice we may dispense with the correction altogether.

The next method is the *chemical* method of registering with the main circuit. I have made full experiments with it, and think that the advantage of avoiding the errors of the relay and primary armature time, are more than counterbalanced by the difficulty and irregularity of the action of the current, the indistinctness of the edges of the scale pauses after the paper is dry, and the irregularity of hygrometric expansion of the paper.

In the experiment of measuring the velocity of the hydro-galvanic current, the method will be useful, as it removes all questions relative to *armature* time, though perhaps it substitutes a longer delay, which I may call *chemical action* time.

On the subject of the velocity of the hydro-galvanic current, I would remark that the experiment of January 23d, between Cambridge, Philadelphia, and Washington, indicates a velocity about one-tenth of that of light. This value, though probable, is by no means certain, and I would wish to speak with caution till more experiments are made.

The third form is the register on a disc with concentric circles, as described by Prof. O. M. Mitchel, in his letters to the Superintendent.

Prof. Mitchel's experience of the despatch and precision of the work, confirms my own. I have no doubt that his method of registration is excellent; perhaps not inferior in compactness, precision, and facility of reading off, to the Saxton sheets. I should wish for the opportunity of personal inspection before giving an opinion conclusively on the subject.

The fourth form of the register is Mr. Saxton's invention of this year. I submit his drawings of the machine. It is somewhat on the plan of his celebrated ruling machine. The cylinder now before the Association contains the culmination of the planet Neptune and the stars near his parallel, printed by me at the Seaton station, Aug. 11, 1849. It might seem that the subject of the place of the planet Neptune is foreign to the purpose of telegraph operations. Such is not the case; for we have used this planet as a fundamental star. I take occasion, therefore, to remark that the observations of the culmination of Neptune on four nights in the month of August at the Seaton station, by Pourtalès and myself, show that my Ephemeris, published by Prof. Henry in the Smithsonian Contributions to Science, agrees with the heavens within half a second of arc. From this close agreement it may be inferred that if the Neptune of Prof. Peirce's theory and my elements were conceived to be a planet, placed side by side in the heavens with the true one ever since its discovery, the two would form a double star of an order so close that not even the great Cambridge refractor could detect their duplicity.

An objection has been urged to the Morse registering fillet, that it is too voluminous for the quantity of matter recorded. This objection and that of expensiveness, occur with more force to the metallic cylinder, however accurate be its indications. To remedy this evil, Mr. Saxton has contrived a sheet of paper which encloses the cylinder and lasts for about two hours of constant work. The sheets and registering fillets now submitted for the inspection of the Association, contain the comparison of the printed record of the culmination of the stars in the Dolphin. The Saxton sheet, the chemical fillet, and the Morse fillet, are triplicate records of the same identical star signals. The result of the reading, as far as experiments have been made, is, that all kinds of registers at the same place read alike. It is worthy of remark that these registers contain the printed record of the transits of both components of the double star Gamma Delphini, printed with ease on each of the forty-five wires of the Wurdeman's diaphragm, making ninety imprints in a culmination.

From my experience in printing the transit of this pair of double stars, I am led to the conclusion, that four stars forming a quadruple star, when at proper distance, may all be printed at the time of their transit over a diaphragm of fifty wires, making two hundred imprints for one transit, a rapidity of playing on the key far below that of good execution on the piano.

The other sheet before you contains the longitude between the Seaton station and Philadelphia. It was registered at Washington. The Morse fillet on the reel now before you is the duplicate Philadelphia register.

This work was performed last Monday night. You will notice a curious occurrence on several occasions that night. Three distinct telegraph operations were going on at once. The Seaton station clock was graduating the time scale for both stations. Two stars differing in right ascension by about the longitude of the places, were in the two telescopes at the same time, and the imprints of the transits are interspered, without confusion on the register. Since one wire at each station gives the longitude of the places, we can find cases where the work of a single second has effected this purpose better than a year's work could do without the telegraph.

The diaphragms of nine and eleven tallies (45 and 55 wires,) made by Mr. Wurdeman, formerly the Mechanician of the Coast Survey, are so nearly perfect in their structure that the probable error of his locating of any single wire, in reference to a normal location with equal intervals, is only four hundredths of a second of time. This precision is a matter of great importance in the use of a diaphragm of so many lines, whose equatorial interval, unless in the case of known symmetry, would need a special determination.

Of all the different kinds of registers here alluded to, I prefer the sheet of Mr. Saxton. One sheet filled on both sides, or two pages, will contain an ordinary night's work. A year's work will make a book of some three hundred pages, on the margin of which may be entered the ordinary remarks for an observing book, relative to the state of the level and meteorological instruments, name of stars observed, and instrumental deviations.

If folded up, or bound and put away for a century, the reduction of the work will then be as easy as at first.

In fact, we may, with the metallic cylinder, electrotype the plate; or, using copper, we may print from it without. And, in the case of the paper sheet, instead of Saxton's graver, with Indian ink, we may employ a pen, with lithographic ink, and multiply copies at pleasure, whenever we choose. When we consider the compactness of the register on Saxton's sheet, we may perhaps find that the publication of transit observations will best be made by the lithographic process, applied to the printed telegraph sheets; thus giving to the world the printed record with all the accuracy of a daguerreotype. The registering fillet now exhibited to the Association, contains the culmination of both limbs of the moon, printed by myself, on the 3d of August last, on 35 wires of the diaphragm. By mean of the results, the probable error of the imprint of a transit of single limb, over a single wire, is the sixteenth of a second; whereas, in 1846, with the great Washington Equatorial, and a power of 300, I found that, with the old method, my probable error, by 66 trials, was twice as great, namely, the eighth of a second. Thus it appears that the measure of precision is twice, and the weight four times, as great, in the new method, as in the old.

No labor of training for the work is needed. Master Langton, the youngest Assistant at the Seaton station, printed the transits of four stars, on the 18th July, for his first trial. The fourth transit is on the register now before you. On reading off Master

Langton's imprints, we find them as accurate as any of our work, and far more so than that of the most experienced observer by the old method.

A hundred wires is a high estimate for a night's work of an observatory, by the old method. I have printed fifteen hundred wires, without fatigue, in one night, by the new. Since each wire is worth four of those of the old method, we have six thousand to one hundred, or sixty to one, as the relative efficiences of the night's observations.

When we reflect, that the probable error of one transit, over one wire, is only the sixteenth of a second, and that with five wires it is only a thirty-sixth part, or three hundredths of a second, it is manifest that one tally, or five wires, is ample for all ordinary work. In fact, one wire is sufficient for most of the purposes of astronomy. I have been led, on consideration of all the facts known from the experience of the Coast Survey, at the Seaton station, to make the following remark relative to the precision of our work, after proper adjustment of the transit instrument, or measurement of its deviations from a normal state: *The printed transit of a fundamental star over any wire of Wurdeman's diaphragm, and that of a star, planet, or comet, whose place is sought, over another wire—both reduced to the centre, on the supposition of uniformity of interval—give the place of the object sought, with a precision not much below that on which rest the present elements of all the bodies in the solar system.*

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[SECOND SERIES.]

Art. XV.—*Observations on the Contrast in the Physical Features and Resources between the Old World and the New World;* by Prof. Arnold Guyot.*

The appearance of Professor Guyot's work on Physical Geography has been briefly announced in this Journal. The pleasure and profit it is calculated to afford, the importance and novelty of its views, the high intellectual and moral tone that pervades it, impel us to give it a fuller notice. The subject is geography;—not the dry *anatomy* of the earth's surface, of which our common school-books treat;—but geography as taught by Humboldt and Karl Ritter, and interpreted anew with fresh vigor and much originality by our author. The work treats of the physical features of the globe with reference to the history of man. The bearing of its peculiarities of outline, of surface, of climate, and of productions, on the distribution of man and the progress of civilization, is the grand subject in hand; and it is ably discussed with a command of a wide range of facts, and great beauty and fertility of thought. Geography is raised to a level with the higher intellectual sciences, and the Christian spirit infused into it gives it a still more exalted character. The various facts and deductions brought forward one after another, are finally made to concentrate upon the one great idea of man's moral destiny.

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* From a work entitled, *The Earth and Man: Lectures on Comparative Physical Geography, in its relation to the History of Mankind*, by Arnold Guyot, Prof. Phys. Geog. and Hist. at Neuchatel, Switzerland; translated from the French by C. C. Felton, Prof. in Harvard University. Boston, 1849. xviii and 310 pp. 12mo.

Prof. Guyot commences by explaining Physical Geography as a description of the earth and of its relation to the life upon it. He says, in the course of his illustrations of the subject, "If the Rocky Mountains bordered the eastern coast of North America, and closed against the nations of the East and of Europe the entrance to the rich valley of the Mississippi; or if this immense chain extended from east to west across the northern part of this continent and barred the passage of the polar winds which now rush unobstructed over these vast plains; let us say even less—if, preserving all the great present features of this continent, we suppose only that the interior plains were more slightly inclined towards the north, and that the Mississippi emptied into the Frozen Ocean;—who does not see that in these various cases, the relations of warmth and moisture, the climate in a word, and with it, the vegetation and the animal world would undergo the most important modifications, and that these changes of form and of relative position would have an influence greater still upon the destinies of human societies, both in the present and in the future?" This paragraph exhibits the aim of the work, which the author afterwards more explicitly states as follows—after mentioning the great problems which physical geography offers for investigation: He says, "We shall endeavor to solve these problems by studying, first, the characteristic forms of the continents, the influence of these forms on the physical life of the globe; then the historical development of humanity. We shall have succeeded, if we may have shown to you—

"1. That the forms, the arrangement, and the distribution of the terrestrial masses on the surface of the globe, accidental in appearance, yet reveal a plan which we are enabled to understand by the evolutions of history.

2. That the continents are made for human societies, as the body is made for the soul.

3. That each of the northern, or historical continents, is peculiarly adapted by its nature, to perform a special part which corresponds to the wants of humanity in one of the great phases of its history.

Thus nature and history, the earth and man, stand in the closest relations to each other, and form only one grand harmony."

In carrying out this plan, the author is borne up by his subject, the works of creation, to the Supreme Intelligence whose beneficent designs are so strongly marked around and within us.

The facts of science are not yet sufficient to sustain beyond a doubt all the conclusions arrived at; still the tendency is apparently in the direction in which Prof. Guyot would lead us: and however the reader may differ in some minor points, he will rise from the work with enlarged views of the earth and its fitness for man's mental and moral development. There are many portions of the volume which we should be glad to transfer to our pages. The chapter on the Relief of the Continents contains views of high importance, which show that the author has studied the world, and not merely a ledge of rocks or an isolated territory. He does not, with the prevalent geological school, regard the elevation of mountain chains as the great events in the physical history of our globe, and the rising of the vast plateaus and plains of the continents as a mere accompaniment; but considers, in view of the amount of evidence in physical geography, the change of level in entire continents as the essential fact, and mountains but the accidents attending the vast changes that have been in progress.

Passing by this and other chapters (or lectures) we cite a portion of Professor Guyot's observations on *the Contrast in Physical Features and Resources of the Old World and the New World,** referring to the work for the continuation of the subject and the many conclusions deduced.

"The most prominent feature of the arrangement of the continents is the grouping of the two Americas in one hemisphere, and that of the four others in another hemisphere. This division of the continents into two worlds is so evident from the first glance, and is at the same time so convenient in practice, that it has passed into common speech as one of those observations admitting no contradiction.

But to bring out prominently the contrast of these two worlds, they must be studied more in detail than we have thus far done; we must compare them, in order to deduce, by the comparison itself, the special character of each. This is what we are going to attempt. We have already seen that they differ in the forms of their relief and in their climate; we shall further see that these fundamental differences produce analogous effects in the organized beings, and in the entire physical life of each of the two worlds. Finally, we shall speak of the manner in which they act upon each other and seem, by their very nature, destined not to live isolated, but to form together a single organism, a grand harmony.

During the whole of this study, please to remember, gentlemen, that we are in the realm of nature, and not in that of history. The America we are seeking to understand is that which Columbus and his successors discovered, still entirely a virgin world, centuries ago; and not the New World of history, of which we shall have to speak later, that has come to plant itself on that soil.

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* These Lectures were delivered by Prof. Guyot in French at the Lowell Institute, in January and February, 1849. The vigorous and eloquent thoughts of the author are well expressed in the elegant translation of Prof. Felton.

A general comparison of the two groups of continents, will call to mind some of the leading features we have already become acquainted with, and add still others.

The Old World and the New World differ in the groupings, and in the number and extent of the continents composing them; in their astronomical situation, with respect to the climatic zones; in the general direction of their lands; in their interior structure. This assemblage of opposite characters secures to each of them a climate, a vegetation, and an animal kingdom, peculiarly their own.

I say first, in their groupings:—

The Old World is composed of four continents. Setting aside Australia, which is only an island in the midst of the oceanic hemisphere, it numbers three, all very near each other, aggregated and forming an oval compact mass, whose extent far surpasses that of every other terrestrial space. It presents a solid extent of land, the most vast, the most unbroken, the least accessible in its centre to the influences of the ocean. The Old World is preëminently the *continental* world.

The New World has only two continents, North America and South America, America and Columbia, as I should like to call them—to render justice where right belongs—if it were not forbidden to change names consecrated by long usage. These two continents are not grouped in one mass, nor placed side by side, but separated from each other, not touching upon their long sides, but by their exterior angles, standing in line, rather than grouped. They are situated in two opposite hemispheres, and thus more distant from each other, apparently, and less neighboring.

The result of this remarkable disposition is that narrow, lengthened, slender form we see in the New World. No portion of the interior is very remote from the sea-coasts; everywhere it gives access to the influences of the ocean, in the midst of which it is placed, like a long island. This form already contrasted with that of the Old World, gives to it its character. The New World is essentially *oceanic.*

The astronomical position, relatively to the climatic zone, is also not the same in the two worlds.

The Old World is, as it were, crowded back upon the north of the equator; it belongs for the most part, to the northern hemisphere and to the temperate zone. Of the three principal continents composing it, the two whose importance is by far the greatest, Europe and Asia, are temperate. Asia penetrates the torrid regions only by the southern peninsulas; Europe at no point; Australia is sub-tropical; Africa only is truly tropical. Even if we take in the last two continents, more than two-thirds of the lands are situated in the temperate regions, one-third only in the equatorial regions. The Old World is then essentially *temperate*.

In the New World the lands are distributed in a manner nearly equal in the two zones and in the two hemispheres. We find that of the countries it includes, those which are the most richly endowed, are situated under the sun of the tropics. Compared with the Old World, the New World is thus essentially *tropical*.

The general direction of the lands, or the direction in which their length extends, is the inverse in the two worlds. The Old World has its greatest prolongation from east to west, in the line of the parallels; the New World from north to south, in the direction of the meridians. Both have a length of about 7,500 miles, but the breadth of the Old World is nearly double that of the New. This disposition is of the greater consequence for the distribution of the climates in each of them, since this configuration coincides, as we have seen, with the interior structure, with the direction of the principal mountain chains and of the table lands. From one end to the other of the Old World, over a space of several thousand miles, the migratory tribes are able to pursue their adventurous roaming course, by following, according to their custom, the great features of relief of the soil, without witnessing any change in the vegetation or the animals that surround them. They change place, but not climate, nor ways of life. This similarity of climates over long spaces is, then, a property of the Old World, and must have singularly favored the dispersion of the primitive tribes.

In the New World, on the contrary, the zones of similar climates are short and numerous; and if we travel over the whole length of the two Americas, we pass twice in succession through all the temperatures, from the frozen climate of the pole to that of the equator, and from the burning climate of the equator to that of the poles. This diversity of climate gives their character to the Americas.

Meantime, the interior structure modifies in the two worlds these climatic relations, in such a manner as to correct the uniformity of climate in the Old by more marked contrasts, and the too great diversity of the New, by gentler and better graduated transitions. We shall see this as we proceed to a closer examination of the structure of the two Americas, which will particularly occupy us this evening.

What characterizes the interior structure of the New World is its simplicity. In place of the variety of the Old World, where, in spite of a few general features common to both, each continent is, as it were, cast in a separate mould, the two Americas seem absolutely formed upon the same plan. This plan may be sketched out in a few lines. Two triangles, their vertices turned to the south, one situated northwest of the other; the long cord of the Rocky Mountains and of the Andes, running the length of the extreme western coast, and binding the two continents together; great plains on the east, forming the larger part of their surface; a slight elevated chain along the Atlantic coast of both, the Alleghanies in North America, the Serra do Espinhaço and the Serra do Mar of Brazil, in South America; finally, in the centre, three short, transverse chains, that of Parime, in the Guyanas, that of Venezuela, and that of the great Antilles, broken into a number of islands;—these, in a few words, are all the essential features of this vast division of the world.

That which constitutes the richness of organization in the continents, is the number and abundance of internal contrasts calling out at once the activity of nature and that of man. The Old World is full of them; America has only a small number, all tending to disappear by reason of the structure itself.

Thus in Asia and Europe, the line of the highest lands, the continental axis, extending from the Himalaya to the Alps and the Pyrenees, divides these two continents into two unequal parts, one north and one south, opposite in climate, in vegetation, and even in races. Scarcely anywhere is the transition from one to the other gradual; almost everywhere it is abrupt and sudden. The table lands of Tubet and frigid Mongolia touch the tropical plains of China and of the Indies; the traveller who passes the Alps, abandons the severe landscapes and the firs of the North, to descend, by a single day's journey, into the ever verdant gardens and the orange groves of fair Italy; he exchanges the cold mists of the North for the sun of the South, and often leaves on one side, the snows and frosts of winter, to find on the other, the warm breath of spring, its verdure and its flowers.

This striking contrast between the North and the South reflected in the character and history of all the nations of Asia and Europe, is doubtless found in America; nowhere is it better known than in this country. But in nature it is almost effaced, it is softened down. It does not form a barrier; it nowhere presents an abrupt change; nowhere breaks the unity. On account of the continued plains of the continent, we see the natural character of the North gradually melt into that of the South. Between the shores of the Frozen Ocean and the Gulf of Mexico there lies the whole distance from the icy regions to the tropics. But it is only slowly, and over long spaces, that we pass through the transition. From the treeless polar plains, where flows the Mackenzie River, whose only covering is the mosses and the lichens, we pass only by degrees to the coniferous forests of Lake Superior; then to the oaklands of Wisconsin: the walnuts, hickories, and the chestnuts of Ohio and Kentucky next appear; farther south, the magnolia and the palmetto already herald the air of the tropics and the neighborhood of the Gulf of Mexico. Two thousand four hundred miles separate the extremes of this scale of vegetation which almost touch each other in the Himalaya.

It is, moreover, to these vast plains, which offer no obstacles to the dissemination of the species, and to the absence of great chains from east to west, that we undoubtedly owe the appearance at the North, of plants and animals that seem to belong only to the tropical regions. It is not without surprise that the European landing on these shores sees the humming bird, that diamond of the tropics, glancing in the sun in a country which winter clothes, during long months, in a thick mantle of snow and ice.

It is the same towards the South, where we see the palm trees and the parrots of the tropics, here and there, as far as the Pampas of Buenos Ayres, much beyond their natural limits.

Thus the contrast between the North and the South is softened, reduced; but it is not annihilated; it exists on a great scale from one of the continents to the other: for North America is temperate, and South America is tropical.

America is cut by the Andes into two parts, east and west, as Asia and Europe are cut into two parts, north and south. But this contrast also is almost neutralized, as we shall soon understand.

The inequality is here carried to the extreme, to such a reduction of one of the parts, that it loses its importance, and, so to speak, its power of reaction. The western coast, dry and barren, has not extent and influence enough to enter upon an effective rivalry with the vast countries of the East. Moreover, the difficulty of communication renders the mutual action and the intercourse between the countries situated at the foot of the two inclinations, still more rare. Finally, the two sides of the Andes, being under the same latitudes, have the same, or nearly the same climate, and only differ in the degree of moisture or dryness falling to their portion. The West of the two Americas is only a narrow strip, not to be compared with the great plains of the East occupying nearly the entire continent, and giving it its character.

America is then less rich in internal contrasts than the Old World, but it has more of unity, because it is more simple. Undoubtedly in this uniformity of structure, in this absence of obstacles to a free circulation from end to end of this world, we are to look for one of the principal causes of that common character, of that American physiognomy which strikes us in all the organized beings of this continent, and which we find again in man himself, in the Indian, all the tribes of whom, from the banks of the Mackenzie River to Patagonia, have the same coppery tint and a family likeness in features, impossible to mistake.

The climate of the New World, compared with that of the Old, is distinguished by the abundance of pluvial waters, in general, by a greater humidity. We have seen in what manner this phenomenon is the consequence of its narrow and lengthened form; of the opening of the great plains—that is, of the two continents almost entire—to the winds of the sea; of the absence of high mountains in the East; in a word, of the configuration and general exposure of this part of the globe. While the Old World, with its compact figure, its vast plateaus, its high lands in the East, receives only an average of 77 inches of water by the year under the tropics, America receives 115 inches. The temperate regions of Europe have 34 inches; North America, 39 inches.

Add to this abundance of water, the extent of plains which permit the development of vast systems of water courses, and you will understand the existence of that innumerable multitude of rivers and lakes, which are one of the most characteristic features of the two Americas. Notwithstanding a much smaller extent than that of the Old World, the New possesses the largest rivers on the earth; the richest in waters, those whose basins occupy the vastest spaces. Where can we find, on the surface of the globe, a river equal to the mighty Marañon, that giant among the rivers of the earth, gathering its waters from a surface of a million and a half square miles, and bearing them to the ocean, after a course of 3,000 miles? This mighty monarch receives in his progress the homage of tributaries, each of which, by its greatness and the abundance of its waters, would suffice for the wants of a whole vast country. Such are the Ucayale, the Rio Purus, the Rio Negro, above all, the Madera, rivalling in importance the river to which it yields the honor of giving a name to their united waters. The farther it advances in its majestic course, the more its proportions increase; and before arriving at the ocean, its broad sheet, from the middle of which the eye cannot reach the banks, seems rather to be a fresh-water sea, flowing sluggishly towards the ocean basin, than a river of the continent. Far from its mouth, the fresh and muddy waters of the Amazon are still distinguished at a glance of the eye from the saline and limpid waters of the ocean; and their slime, borne along by their currents, goes to form, farther north, a new soil on the shores of the continent.

In the other continent, the Father of Waters, the mighty Mississippi, the second of the rivers of the earth, equals in length the Marañon itself; for its winding course is 3,000 miles. But its basin covers only from 8 to 900,000 square miles. Who does not know the importance of tributaries like the Missouri, which wrongly gives up its name for that of its less powerful brother; like the Ohio, the Beautiful River, the stream with transparent waters; like the Arkansas, and so many others composing that vast system of arteries that vivify the whole West, and that are destined to assume daily a greater and greater importance? And these immense rivers are not isolated. At the side of the Marañon, the La Plata has a course of not less than 1,900 miles, and more than a million of square miles send it their waters. At the side of the Mississippi, the St. Lawrence has a course of 1,800 miles and a basin of nearly a million of square miles.

The Old World offers nothing similar. The greatest of its rivers, the Yan-tse-Kiang in China, has a course of only 2,500 miles. The Ganges and the Nile are far from equalling it. The Volga, the greatest of the rivers of Europe, exhibits a course of only 1,700 miles: and if it were necessary to enumerate in America rivers like the Rhine, so celebrated, it would be almost by hundreds that we should have to cite them.

And what shall we say of the abundance of its lakes? The group of the great lakes of Canada, so characteristic of North America, finds nowhere a parallel. It contains at once the largest lakes in the world, and the greatest mass of fresh water united on the surface of the continents. These vast seas of fresh water, together with the St. Lawrence, cover a surface of nearly 100,000 square miles, and it has been calculated that they contain almost one-half of all the fresh waters on the surface of our planet. They, too, are not alone, and a glance of the eye at the map, enables us to perceive in the North a multitude of lakes but little inferior in extent: the lake Athapescow, Winnipeg, Slave Lake, the Great Bear, are worthy to figure side by side with the lakes of Canada and of the St. Lawrence.

The rivers and the lakes are the wealth, and justly form the boast of America. No continent possesses so great a number, or those of so large extent, so well provided with water, so navigable. Not only do they fertilize the rich countries they traverse, but they are now, and will become still more so, the great highways of commerce between all the parts of this vast world; we already see enough to hope everything of the future.

Thus, gentlemen, the watery element reigns in the New World; add to this, that although half of its lands are exposed to the rays of the tropical sun, yet, all the conditions being equal, America is, on the whole, a little less warm than the Old World, and we shall have the essential features of its climate,—the oceanic climate. This is what America owes to the fundamental forms and the relative disposition of its lands; while the Old World is indebted to the preponderance of land for its dry and continental climate.

Let us now follow out the consequence of these physical circumstances upon the development of organic beings, and the character of the New World will come out in all its clearness.

The warm and the moist—these are the most favorable conditions for the production of an exuberant vegetation. Now, the vegetable covering is nowhere so general, the vegetation so predominant, as in the two Americas. Behold, under the same parallel where Africa presents only parched table lands, those boundless virgin forests of the basin of the Amazon, those selvas, almost unbroken over a length of more than 1,500 miles, forming the most gigantic wilderness of this kind that exists in any continent. And what vigor, what luxuriance of vegetation! The palm trees, with their slender forms, calling to mind that of America itself, boldly uplift their heads 150 or 200 feet above the ground, and domineer over all the other trees of these wilds, by their height, by their number, and by the majesty of their foliage. Innumerable shrubs and trees of smaller height fill up the space that separates their trunks; climbing plants, woody-stemmed climbing lianos, infinitely varied, surround them both with their flexible branches, display their own flowers upon the foliage, and combine them in a solid mass of vegetation, impenetrable to man, which the axe alone can break through with success. On the bosom of their peaceful waters swims the Victoria, the elegant rival of the Rafflesia, that odorous and gigantic water lily, whose white and rosy corolla, fifteen inches in diameter, rises with dazzling brilliancy from the midst of a train of immense leaves, softly spread upon the waves, a single one covering a space of six feet in width. The rivers rolling their tranquil waters under verdurous domes, in the bosom of these vast wilds, are the only paths that nature has opened to the scattered inhabitants of these rich solitudes. Elsewhere, in Mexico and Yucatan, an invading vegetation permits not even the works of man to exist; and the monuments of a civilization comparatively ancient, which the antiquary goes to investigate with care, are soon changed into a mountain of verdure, or demolished, stone after stone, by the plants piercing into their chinks, pushing aside with vigor, and breaking with irresistible force, all the obstacles that oppose their rapid growth.

South America, and particularly the basin of the Amazon, is the true kingdom of the palm trees; nowhere does this noble form of vegetation show itself under a greater number of species. This is a sign of the preponderating development of leaves over every other part of the vegetable growth; of that expansion of foliage, of that *leafiness*, which is peculiar to warm and moist climates. America has none of those plants with slender, shrunken leaves, like Africa and New Holland. The Ericas, or heather, so common, so varied, so characteristic of the flora of the Cape of Good Hope, is a form unknown to the New World. There is nothing which resembles those Metrosideri of Africa, those dry Myrtles (Eucalyptus) of New Holland, and willowleaved acacias, the flowers of which shine with the liveliest colors, but whose narrow foliage, turned edgewise to the vertical sun, casts no shadow. Everywhere, long and abundant leaves, an intense verdure, a strong and well-nurtured vegetation, these are what we find in tropical America.

North America, in spite of its more continental climate, shares no less in this character of the New World. The beauty and extent of the vast forests that cover its soil, the variety of the arborescent species composing them, the strong and lofty size of the trees which grow there, all these are too well known for me to stop to describe them. It is because this continent adds to a more abundant irrigation, a soil slightly mountainous, almost everywhere fertile, securing to it always an equal moisture, a more abundant harvest of all the vegetables useful to man.

Not only is the vegetation abundant in the New World, but it is universal, and this is a farther characteristic distinguishing it from the Old. We do not see there those vast deserts, so common in the other continents, and occupying a considerable portion of their surface. The Deserts of California and that of Atacama are exceptions, and, compared with those of Africa and Asia, scarcely seem made for anything except to serve as specimens. The llanos of Orinoco, which their geological nature dooms apparently to the fate of Sahara, are copiously watered during the rainy season, and are covered then with an admirable vegetation. Life, which seemed almost to slumber, almost extinguished, springs up again more beautiful and more vigorous. To the powdered sand swept along by the winds, succeed rich pastures, where range a multitude of indigenous animals, mingled with herds of horses, and wild asses, coming from Europe; and thousands of reptiles buried in the watery slime during the dry season, reappear, and fill again with life the temporary rivers and lakes with which these valleys are then overflowed. The pampas themselves are not without vegetation, and support at all times numerous herds. And who is ignorant that the vast prairies of the Mississippi and the Missouri produce every year an abundant vegetation, on which feed the bisons and the other wild tenants of the country.

But what becomes of the animal in the peculiar kingdom of vegetation? Blessings are shared; all treasures do not belong to one country alone. This luxuriant vegetation, it might be said, seems to stifle the higher life, in the animal world. Animal life is, as it were, overruled, enfeebled; it does not occupy here the first rank, which is its due; for that which favors it is dry heat, the continental element.

From one end to the other of the animal scale, the families that seem to give to these countries their character, by the number of their species and by their relative abundance, are those which connect themselves, by their mode of life, with the aqueous, or with the vegetative element.

Hence, nothing is more splendid, more sparkling, than the insect world in South America. The inexhaustible variety of their species, the brilliancy of their colors, the size of their bodies, make them one of the most beautiful ornaments of these regions. Here live the Hercules beetle, the largest of the Coleoptera; and those brilliant butterflies with broad wings, the Menelaus, the Adonis, the Achilles, whose varying colors glitter in the sun like diamonds. But why be astonished? The existence of this little animal world is almost altogether dependent on the vegetation; the wealth of the one must create the wealth of the other.

Among the vertebrates, no family is so largely represented as that of the reptiles, for moisture is their element, and the rivers and temporary lagoons of the rainy season are peopled with Caimans, the crocodiles of the New World; the Iguanas, the most gigantic of the lizards; the Basilisks and other species, which multiply in the warm and still waters. The forests harbor in great numbers serpents of every form and figure, even to those monstrous boas, that are the terror of the natives themselves. They seem to be at home in this country.

But among the superior animals, development seems to be arrested; it is incomplete. The prevailing types are at the same time the inferior types. Among the birds, the stilt-plovers, inhabitants of the marshes and the shores, of which the number of species surpasses far, in America, that of any other continent. In the mammifera, the order of Edentata, the Armadillos, the Pangolins, the Ant-eaters, the Sloths, which characterize, more than any other family, the fauna of South America, not only in the present epoch, but also in the geological ages. And if we seek representatives of the higher orders, we find them less numerous in species, smaller in size; in a word, far inferior to the corresponding animals of the Old World. In the order of the Pachyderms, instead of the elephant, the rhinoceros, the hippopotamus, those giants of the Old World, the feeble and harmless tapir and the pecari. In the Ruminants, instead of the camel and the dromedary, the lama of the Andes, which reaches only half their size. Instead of the lordly lion of Africa, and the ferocious tiger of the islands of the Ganges, the Ounce and the Jaguar of the forests of Brazil, which are scarcely more than large cats. In the monkeys, finally, those with a prehensile tail, which are peculiar to America, are reckoned among the least perfect, the lowest of their order in the scale of organization.

Not only are the superior animals ill represented on this continent, but they have not the strength, nor the indomitable courage, not the ferocity, nor the intelligence of the similar creatures of the Old World. In all tropical America especially, as we see, the whole animal kingdom remains in an inferior condition. It is subjected to the watery element, and to the vegetable world; for in those regions where vegetable life is the superior, animal life stands but in the second degree.

North America, however, in consequence of her more continental character, possesses some superior types, which recall to mind, and perhaps equal, those of the Old World. The majestic bison, the deer, the elk, and the bear, give evidence of that same vigorous northern nature which predominates in the temperate continents, and of which, as we shall see, North America possesses her share.

Man himself, the indigenous man I mean, bears in his whole character the ineffaceable stamp of this peculiarly vegetative nature. Living continually in the shadow of those virgin forests which overspread the earth that he inhabits, his whole nature has been modified thereby. The very copper hue of his complexion indicates that he lives not, like the negro, beneath the scorching sunbeams. His lymphatic temperament betrays the preponderance in his nature of the vegetative element. The Indian is of a melancholy, cold and insensible race. "Foreign to our hopes, our joys, our griefs," says a traveller, "it is rarely that a tear moistens his eyes, or that a smile lights up his features." The most barbarous tortures cannot extort from him a single complaint, and his stoical indifference is disturbed only by vengeance or jealousy. If he sometimes exhibits a display of prodigious muscular force, he is yet without endurance. Who knows not that when the first invaders of the New World endeavored to compel the inoffensive Indians, who had received them as gods, to the rude labors of the mines and the cultivation of the soil, these men of the woods, incapable of enduring fatigue, perished in agony by thousands? And it was thereupon that the Europeans substituted for the Indian the robust and vigorous native of the Old World, the negro, who, still to this day, used as the instruments of the white man's labor, endures, I had almost said, daily, a degree of toil equal to that which destroyed the native of the country.

The social condition of the Indian tribes is tinctured, in an equal degree, by the powerful influence of his vegetative character. The Indian has continued the man of the forest. He has seldom elevated himself above the condition of the hunter, the lowest grade in the scale of civilization. The exuberance of the soil has never been of value to him; for he asks not of the earth his nourishment. He has never even ascended to the rank of the pastoral man. With him no domestic animals are maintained to feed him with their milk, or clothe him with their fleeces, as they are by the nomadic races of the Old World. From one extremity of America to the other, we find the same lamentable spectacle; the people of the elevated table lands of Mexico and Peru, are the only exception to this picture, and this exception goes far to establish the influence of the vegetative and humid nature of the lower plains of America. For if these nations do not exhibit the same character of inferiority, if they have raised themselves a little higher in the sphere of humanity, by the aid, perchance, of elements foreign to their own continent, it cannot be for other cause than that, living in those heights, those aërial islands, above the influence of the hot and humid atmosphere, they have been removed from the potency of its action.

Such, gentlemen, is the order, the admirable connection of the phenomena of nature with each other. The conformation and position of the New World give to it a hot and watery climate; this impresses its own character on all the organized creation. Man himself, the one being preëminently free, is liable to its influence, in proportion as he neglects the exertion of those superior faculties with which he is endowed for the conquest and subjugation of that nature which was intended, not to govern, but to serve him.

We may rest, then, in this conclusion, that, as compared with the Old World, the New World is the humid side of our planet, the *oceanic*, *vegetative* world, the passive element that awaits the excitement of a livelier impulse from without. Such is the America of Nature, such was it before the arrival of the man of the Old World. We know already, and we shall see better yet hereafter, all that his superior intelligence has been enabled to effect in the way of improving upon nature."

ART. XVI.—*On the relation of the Laws of Mechanics to Perpetual Motion*;* by JEREMIAH DAY, late President of Yale College.

I CAN not engage to furnish any infallible remedy, for the mortifying disappointments which abound in this fascinating field of investigation; yet it may not be altogether a waste of time, to pay some little attention to a subject which has levied such heavy contributions, on the inventive faculties of modern mechanicians and philosophers. The hints which I propose to suggest will be principally on the *nature* of perpetual motion, the *benefits* to be expected from it, the *difficulties* to be encountered by the inventors, and the methods by which we may form an opinion whether it has been actually attained.

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* *Messrs. Editors*—If it be consistent with the purpose of your invaluable Journal, to admit upon its pages a paper which offers to the attention of the readers nothing original, no newly discovered principles of science, no improved combinations of machinery; the following plain thoughts on the application of the established laws of mechanics to the subject of *perpetual motion* are at your disposal.

Very respectfully, yours, &c.,

New Haven, July, 1850. J. DAY.

Perpetual motion is a motion continued without ceasing, and without any renewed application of force. A machine may be said to possess a principle of perpetual motion, if it continues to move, as long as it is kept in repair; and if it requires no new force to be applied to it from without. It is no part of the requisition concerning perpetual motion, that the machinery should never be out of repair. If it goes when it is in order, that is all that is demanded. What is looked for, is not perfection in the construction of the apparatus, but an unfailing moving force. On the other hand, it is required, that this force belong to the machine itself; that it be not an application from without. A stream of water may run continually. It may be applied to turn the wheel of a mill. It may in this way, become a never failing moving force. If the mill could be kept always in repair, the stream might be sufficient to turn it, as long as the world stands. But this is not what is meant by the perpetual motion of a machine, as the expression is commonly used. The moving force is here no part of the mill; it is applied from without. What is wanted is a principle of motion within the machine itself; or at least, so connected with it, as to accompany it wherever it may be removed.

It is farther expected that the moving force should require no new supply of *materials* to keep it in action. In the steam engine, the moving force is within the machine; and its agency may be continued without interruption. But a constant supply of fuel is necessary, to keep it in operation; and there is a continual demand for labor, to furnish the fuel. To save this expense of materials and labor, is the very purpose for which perpetual motion is wanted.

It is this which renders the proposed invention so highly important. Extravagant as the expectations of many ardent inventors may appear, there is reason to believe, that in this case, they would be more than realized, if the long sought for principle could once be laid hold of, and brought into general operation. It would be of no great use perhaps, to produce an instrument which would *merely go*, a wheel, for instance, which would revolve continually, without having force enough to result in any valuable product. A sawmill which would run of itself would be an object of curiosity; but would be of very little practical use, if the saw merely played up and down, without cutting the timber. The force which is necessary to put a machine in motion is generally much less, than that which is requisite to accomplish the object for which the machine is constructed. But there is reason to believe that if a perpetual moving force could once be discovered, it might be increased, to any desirable extent;

that if a power could be found which would continually overbalance the resistance of the air, and the friction of the parts of the apparatus, it might be so multiplied, as to produce any of the effects for which force is required in the arts. If for instance the moving principle were a weight, and ten pounds could be so applied as to preserve an uninterrupted motion of the machine, a hundred pounds would accomplish much more. As the weight might be easily enlarged, to almost any extent whatever, there would scarcely be any bounds to the effects to be produced. The vast expense now incurred, in providing reservoirs of water, in producing steam, in procuring labor, &c., as moving forces, might be wholly dispensed with. In the various manufacturing establishments, in this country, and in Europe, millions of dollars might be saved, in a single year. The invention might be considered a mine of wealth, even to a nation. It would not, perhaps, necessarily follow, that a power which would put in operation a *standing* machine, as a mill or manufacturing establishment, would be adapted to the *progressive* motion of a plow or a coach. But it would seem less difficult to make such an application of a moving force, than to originate the force itself. If this additional improvement could be effected, our oxen and our draft horses might be relieved from their labors; our carriages would be seen rolling through the streets of themselves; and we should be brought near to the state of perfectibility predicted by Godwin, when a plow need only to be let loose into a field, to accomplish the work of tillage.

Mankind have not been insensible to the immense advantages to be derived from perpetual motion. There is perhaps, no one subject on which the inventive faculties have more frequently been called into exercise. It is doubtful whether a single year, or even a single week has passed, for centuries, in which it has not occupied the earnest attention of some one. Many are probably employed in the search, who never disclose their attempts to the public. They have a double motive for keeping the secret; on the one hand, to secure to themselves the rewards of their success; on the other, to conceal their disappointment, in case of a failure. Persons of very various descriptions and occupations have been engaged in the pursuit. The man of science and the illiterate mechanic, have both eagerly contended for the prize, and generally with equal success.

It is natural to inquire, what can be the cause which has produced such universal failure, where the zeal for attaining the object has been so ardent, and so long continued. What are the difficulties which, with so provoking a pertinacity, unceasingly throw themselves in the way of the sanguine inventor? It would be in vain to attempt to enumerate *all* the obstacles which a subject so fruitful in disappointments presents. They will vary according to the means which are used to effect the object, and according to the characters of the different projectors. The man of science will be liable to embarrassments of one kind; the mere mechanician, to those of another. The chief impediments in the way of the man of science are certain *general principles*, denominated laws of nature. His ingenuity is exercised in endeavoring to evade these; but they obstinately meet him at every turn; and in spite of all his windings, he finds himself brought back to the same ground from which he started.

Nothing but what is capable of producing *motion*, can be the cause of *perpetual* motion. The moving forces which are commonly applied to machines are weights, springs, running water, steam, wind, and the strength of animals. Of these, water, wind, and animal strength can not produce what is commonly meant by perpetual motion, because they are not constituent parts of the machine. They are forces applied from without. But steam, springs, and weights may belong to the machine itself. Of these, the weight of a heavy body is that which is generally made use of, to produce perpetual motion. A weight is a very simple moving force, and may be made very powerful. The only difficulty with respect to it is, that it produces its effect only by *descending;* and that when it reaches the ground, its operation ceases. If it could be made to descend and then ascend, with the same force, it might keep a machine in perpetual action.

The difficulty is not, as some seem to have supposed, that a weight can move a body in one direction only. It can produce motion in *any* direction; not indeed by mere pressure, but by the aid of some very simple apparatus, for instance, a cord passing over a pulley. Nothing is easier than to change the direction in which a given power is to act upon the object to be moved. A weight may make a body either ascend, or descend, or move horizontally. But the real difficulty is, that the power will not move at all, after it has reached the ground. Its operation then ceases entirely. The great thing wanted is not a change in the direction, but a *continuance* of the motion.

Neither does the obstacle to perpetual motion consist in the law, that matter is incapable of originating motion in itself, or of effecting any *change* in its own motions. The difficulty lies not in *beginning* the motion, but in rendering it perpetual. The labor and expense of merely putting a machine in operation would be of no account, if the movement would only continue. Now the first law of motion, instead of obstructing the continuance of the action, is the very principle on which that continuance depends, unless there is a renewed application of external force. There is one known instance of actual perpetual motion, the revolution of the heavenly bodies. This is owing to the fact, that they are incapable of putting a stop to their own motion, and that there is nothing else to stop them. But if matter were endowed, like animals, with a principle of voluntary motion, it would be as easy for it to cease to move, at pleasure, as to begin to move. It would then be as difficult to produce perpetual motion in a machine, as in a horse or an elephant.

Some of the principles which really stand in the way of the inventors of perpetual motion are the following.

1. In every machine, there is some *loss* of motion, from friction and the resistance of the air; and commonly a much greater loss, from the expenditure of force, in producing the effect for which the machine is designed. When a certain momentum is given to a body, it will continue the same, till there is some cause to vary it. A wheel suspended freely on an axis would revolve with a uniform velocity, if friction and the resistance of the air could be entirely removed. Perpetual motion would then be a thing of course. But these obstructions it is impossible to avoid; and they necessarily occasion a continual loss of motion.

In addition to this, a machine, to answer any practical purpose, must not only *go*, but it must also be capable of a constant expenditure of force upon the effect to be produced. A slitting mill, for instance, must not only be kept in motion, but must furnish a continual supply of force, to separate the iron. The loss of motion on this account is far greater than that occasioned by friction and resistance of the air. Both must be compensated by a renewal of force from some quarter or other. It is the aim of the inventor of perpetual motion, so to arrange his apparatus, that this new supply shall be furnished from the machine itself; that it shall not be dependent on any application from without. But in attempting to accomplish this object, he finds himself under the necessity of encountering a second unaccommodating principle.

2. Every body which communicates motion to another, loses an equal portion of its own motion. In other words, action and reaction are equal. It follows from this, that no portion of matter can communicate to another portion a greater momentum than it possesses itself. If that part of a machine in which the moving force begins to act could produce, in another part, a motion greater than its own, we might obtain a *multiplication* of force; and in this way, we might secure a surplus, to supply the deficiency occasioned by friction, &c. But after all the trials which have been made upon bodies in every conceivable variety of condition, they obstinately refuse to communicate what they do not themselves possess. On this fact is founded a third important principle.

3. *No combination of machinery* produces any real increase of force. This is the fact with respect to each of the instruments called mechanical powers taken singly; and it is equally true, in whatever way they may be combined with each other. The use of all apparatus of this kind is not to create force, nor to increase it, but merely to apply it. It is true, indeed, that a mechanical power may be so contrived, that a small weight may raise a very great one. But it will raise it a very short distance only. If one is a thousand times as large as the other, the latter must descend a thousand feet to raise the former one foot. So that the *momentum* of the large body is no greater than that of the smaller one. There is, therefore, no increase of force obtained.

One or two cautions are necessary, however, in estimating the velocities of the power and the weight. In the first place, the velocity is to be reckoned *in that direction* in which the moving force of the body acts. Thus if a body moves down an *inclined plane*, the moving force is gravitation, which acts towards the center of the earth. The velocity, when we are calculating the equilibrium, must be estimated in this direction. In the second place, there must be brought into the account, *that part* only of the power which is concerned in producing the effect. If a weight act *obliquely* on the arm of a lever, a part of its force will be lost. This must be thrown out of the estimate.

With these qualifications, we shall find, that however complicated may be the apparatus, the power will be to the weight in equilibrio, as the velocity of the weight to the velocity of the power. As their momenta are equal, there is no increase of force produced by the machinery. This is a proposition, however, which one who is in pursuit of perpetual motion can not be brought fully to believe, till he has learned it by mortifying experience. He expects, by some peculiar arrangement of his levers, and wheels, and inclined planes, to make it appear that this is only a *theoretical* maxim, intended to answer the purposes of speculative philosophy. He seeks after modes of combination which may vary, as much as possible, from those already in use, that he may fall upon the grand secret, in some mysterious disposition of parts, which has hitherto escaped observation. But the effect of all this is commonly to *diminish* the power which he wishes to increase. For although, according to the received laws of mechanics, no combination of machinery will create force; yet it is very easy, by an unskillful arrangement, to destroy motion.

After all, the projector finds an unfailing source of motion in the *weight* of a heavy body. Though he may acknowledge, perhaps, that machinery will not of itself produce force, yet he considers that *gravitation* is a power which is perpetually operating, and that, if he can only arrange his apparatus so as to catch this force, and apply it to his use, he has all that he wants. He here finds a very important exception to the general law, that a body is incapable of putting itself in motion. Matter has a continual and powerful tendency to move towards the earth. A body needs only to be left to itself, to descend with a force proportioned to its weight. But he is driven even from this refuge, by a fourth general principle.

4. A body, *by its weight*, communicates motion in no other way than by *descending;* and when it has once reached the earth, its operation ceases, till it is raised up again, with a force equal to that with which it descended. This does not mean that a body can, *in no case*, communicate motion except by descending itself. A heavy body moving in *any* direction may impel another in the same direction. A cannon ball may drive before it the object which it strikes. This is not done, however, by the weight of the ball, but by the momentum which it has received from a foreign force. What we are now considering is the motion produced by the *gravity* of the body, not that which is occasioned by the application of mechanical force from without. Neither does the principle just stated imply, that a body may not, *by its weight*, cause *another* body to move in any direction except towards the earth. The weight in one scale of a balance may cause those in the other side to rise. But to do this it must itself descend. Nor in the third place, is it to be understood, that a body can not by its weight, have an effect of *any* kind without descending. It may, even in a state of rest, have great influence in *preventing* motion. It may be a powerful *resisting* force, but it is not then a moving force. In preserving the equilibrium of bodies *at rest*, very great advantage may be derived from the application of the instruments called mechanical powers. By means of a lever or an inclined plane, one pound may be made to balance a thousand. Archimedes might have held a world in equilibrio. But the moment the lever is put in motion, the comparative importance of the smaller body is lost. What is gained in weight is lost in velocity.

With these explanations, we may consider the principle as universal, that no body produces motion by its weight, except by descending. If, for instance, a heavy body is laid upon an inclined plane, this plane may move horizontally. But unless the *weight* descends, the motion of the plane is owing to some other cause than the pressure of this weight.

Now the great difficulty in making the gravity of a body a source of perpetual motion is: that the body must soon reach the ground, that in descending it acquires only a certain degree of momentum, that it can communicate no greater momentum to the machine, and that, in order to repeat the operation, there must be a force at least equal to this, to bring it back to the height from which it has descended. There is, therefore, no force at all derived from the weight, except during the period of a single descent, and that only equal to the power which had been applied to raise it up to the point of starting. It will be said, perhaps, that the weight may be made to restore itself, that it may acquire a velocity in falling, sufficient to raise it to the same height again, So it may. The ball of a pendulum may raise itself to the same point from which it started, or nearly so. But it can do nothing more. The force acquired in the descent will be all expended in the ascent. There will be nothing left to be applied to any machinery.

There is no avoiding of this result, unless some way can be contrived to make the body either acquire a greater force by falling, or expend less in rising. No method has yet been devised, to bring a body to the ground by its weight, with a greater force than that which it acquires by falling *perpendicularly.* It may be made to roll down an inclined plane, to descend on the arc of a circle, on the arm of a lever, or along a series of lines differently inclined to the horizon. But in every such case, though it is easy to *diminish* the force of the descent; yet there is no way of *increasing* it, but by the application of a foreign impulse. On the other hand, a body can, by no device, be raised up to its original height, but by a power equivalent to that which it acquires in descending. There is, according to the received laws of mechanics, no way in which it may be brought back again, with a less expenditure of force than that which is necessary to raise it up *perpendicularly.* It may be carried round in such a manner as to employ a *greater* power; but nothing *less* than this will be sufficient to restore it.

But may not advantage be taken of some of the *mechanical powers*, to effect the object with more economy of force. Suppose the weight be made to *descend* on the longer arm of a lever, and to *ascend* on the shorter arm. If one be twice as long as the other, may not one pound raise nearly two pounds? It may. But it will raise them only half as far as it moves itself, so that nothing is gained by *this* expedient. Such is the uniform result of the projector's devices to bring up his weight with a less force than that which it acquires in falling perpendicularly. Like the stone of Sisyphus, in spite of all his efforts, it is forever rolling back upon him.

We shall be brought to the same conclusion, by another view of the subject. No body of machinery has any tendency to move by its weight, any longer than this motion will cause the *center of gravity* to descend. This is a principle of very convenient application, because it brings us at once to the result. We are under no necessity of inquiring into the peculiar *structure* of the machine. Whatever be the arrangement of the parts, as soon as the center of gravity of the whole has reached the lowest point, the motion will cease, except that it may continue a while, from the momentum already acquired.

We may, upon this principle, easily perceive the defect of those numerous perpendicular *wheels*, which have been formed with cavities in the radii or other parts, so as to contain fluids or balls rolling alternately to and from the center. The object here is to have the weights near the *axis*, while they are ascending, and near the *periphery* when descending, so as to act upon the principle of the wheel and axis. The fallacy is the same here, as in the longer and shorter arms of the lever. But to detect this, there is no necessity of examining the particular structure. Whatever be the disposition of the parts, when the center of gravity of the wheel and its contents has reached the lowest point, the tendency to move, from the weight, is at an end. The defect of the contrivance is also evident from the consideration, that as the wheel revolves, each of the balls must rise to a *certain height*, and it is immaterial by what *route* it arrives there, whether by going round on the periphery, or taking a shorter course near the axis.

Similar difficulties will be presented, if instead of the weight of a *solid* body, we substitute the pressure of a *fluid*. According to what is called the hydrostatic paradox, a pound of water may balance and set in motion a quantity ever so great. But the motion will not, perhaps, be more than a thousandth part of an inch, before the effect will cease.

After dwelling so long upon the weight, as a moving force, it will not be necessary to enter into a particular consideration of the action of *springs*. The difficulty, in the two cases, is nearly the same. A spring which is coiled up, as in a watch, produces its effect by expanding. When it is unbent, its action ceases till it is wound up again; and to wind it up requires a force equal to that with which it expands. There is, therefore, no balance left, for the purposes of machinery.

In the case of *steam*, the continuance of the motion is to be sought for, not upon mechanical, but upon chemical principles. Here perhaps there is more reason to hope, because the ground has not been so long and so thoroughly explored. But it is not improbable, that the balance of *affinities* in chemistry, will prove to be as untractable, as the balance of momenta in mechanics. A similar remark may be applicable to the imponderable agents, electricity, galvanism, and magnetism.

Some of the difficulties which lie in the way of the *man of science*, in his pursuit after perpetual motion, have now been stated. But perhaps this is not the class of persons which are most likely to succeed, in this field of investigation. The invention, if it should ever be made, may proceed from some one who has little or no knowledge of the laws of mechanics. The philosopher commences the inquiry with ardor; but soon stumbles upon one of his unyielding general principles, and then abandons the pursuit as hopeless. The uninformed mechanic is not so easily disheartened. If he fails in one attempt, he sees no reason why he should not succeed in the next. Perseverance supplies the want of skill. His very *blunders* may turn to his advantage, by leading to combinations of machinery which a person of more scientific views would have rejected without trial. *He* however is not exempt from embarrassments. They are mostly of a nature not to be particularly described. But they all terminate in one; his machine *won't go.*

It must be acknowledged, however, that although this is the general result, it is not universal. There is, here and there, a solitary exception. A man, after years of thought, and toil, and disappointment, finds at length the object of all his wishes attained. His machine goes. His labors are at an end. His fortune and his fame are secured. He has shown himself superior to all the pretenders to science and mechanical skill. His name is to go down to posterity, in the same rank with Bacon and Newton. But in the intoxication of success, one thing seems to have escaped him. He has forgotten that all *motion* is not *perpetual* motion. His machine stops. His dream is ended; and he awakes to the realities of the life of a sober mechanic.

Must we then be driven to the conclusion, that perpetual motion is absolutely and forever impossible? Shall we obstinately close our eyes and ears against all proof which may be offered of its actual existence? Shall we reject the testimony of our senses, when we see the machine really in motion? When a man professes to have made the great discovery, and calls upon us to accede to his pretensions, we have a right to suspend our opinion, till he has made good his claim, either by shewing the *principle* on which it depends, or by furnishing the proof by *actual trial.* If a new principle is advanced, in opposition to those hitherto received, we may safely admit it, when it has stood the test of as thorough an investigation as they have. The established laws of mechanics have been the subject of strict examination for centuries; they have been turned in almost every conceivable point of view, for the very purpose of eliciting from them perpetual motion; they have been scrutinized by the profoundest mathematicians, and the most skillful experimenters; they have been put to the trial, in a thousand different forms of machinery. Almost every mechanical instrument now in use exhibits experimental proof of their soundness. When any *new* principle can plead as much in its favor, it may fairly be put in competition with the old ones.

But the inventor, though he may not boast of *theory* on his side, has that which is of far greater importance, the support of *fact*. His machine *goes*. So does a time piece go. It may be made to go, for a whole year together, without being wound up. But this is not *perpetual* motion. In a clock, a force is wanted to supply the loss from friction. If the instrument is nicely constructed, this loss may be very small. A large weight may furnish the requisite supply, for a long time, without coming to the ground. But when it has descended as far as it can, its power is exhausted, and the motion ceases. To determine from trial whether any particular machine has an unfailing principle of action, we must wait till the force first applied has had time to spend itself. If we are impatient to come to a more speedy decision, there is a way in which the point may be soon settled. The apparatus may be so well adjusted, that it may take weeks or months, perhaps, to exhaust the moving force, in merely overcoming the friction. But let it be required to do something more. Instead of merely going, let it be applied to some practical purpose. Let it be employed, for instance, in the grinding of grain, or the sawing of timber. In proportion as the resistance is increased, the time of its action will be shortened, if, like other machines, it is dependent on a renewed application of force from without. But if it possesses a perpetuating principle, this may be made to supply that part of the loss of momentum which proceeds from the resistance of the grain or the timber; as well as that which is owing to friction and the air. In this manner, the instrument may be brought to the test of experiment, in a very short time.

With respect to any supposed invention, in years past, of an instrument for perpetual motion; we have only to inquire, whether it is now in operation, in our manufacturing establishments of every description; whether our mills, and forges, our steamboats, and our railroad cars are actually moved by it. An improvement which is to produce so complete a revolution in practical mechanics, could not long be concealed, or confined to the inventor. It would be coveted and circulated, as eagerly as a bank of guineas. A man professes to have discovered an inexhaustible treasure. He has unfolded a secret, which thousands have sought for in vain. He has opened a mine of gold, which is accessible to every one. Its value is beyond all computation. And yet, strange to tell, it lies neglected and forgotten, neither wrought by himself, nor by any one else.

Art. XVII.—*Contributions to the Mycology of North America;* by Rev. M. J. Berkeley, of England, and Rev. M. A. Curtis, of South Carolina.

101. Polyporus rhipidius, Berk.—Ad truncos putridos. Sept. —Ohio (Lea); Santee Canal, S. C. (Ravenel.)

102. P. valenzuelianus, Mont.—Ad truncos emortuos. Santee Canal;—Ravenel.

103. P. epileucus, Fr.—Ad truncos Pini. Autumno. Society Hill and Santee Canal.

104. P. rigidus, Berk.—Ad lignum cariosum. Hieme. Mr. Ravenel.

105. P. (Anodermei) fissiles, Berk. and Curt.;—albus; pileo dimidiato vertice elongato rugoso hic illic aculeato-setoso; intus fibroso-fissili insigniter zonato; poris mediis subrotundis acie obtusiuscula.—Autumno. On old stumps. Society Hill, S. Car.

Cap 6 in. broad, 2 long, or, with the vertex, 3½, undulated, with numerous raised lines which are sparingly aculeato-setose; substance splitting into fibres, zoned throughout; pores about $\frac{1}{30}$ in. broad.—A fine species belonging to the same section as P. *spumeus*, remarkable for its strongly zoned highly fibrous substance; allied to *P. borealis*, but with larger pores, firmer dissepiments, and a more fibrous texture.

106. P. senex, Mont.—Ad truncum. Autumno. Santee Canal, Mr. Ravenel.

107. P. vellereus, Berk.—Oregon. U. S. Exploring Expedition.

108. P. Lindbladii, Berk.—Ad truncos dejectos. Autumno. Ravenel.

109. P. laceratus, Berk.—Ad truncos emortuos præsertim Quercuum. Hieme. Vere. N. and S. Car.

110. P. Floridanus, Berk.—Ad truncos emortuos Myricæ, &c. Hieme. Ravenel.

111. P. arcticus, Klotseh.—Ad truncos emortuos. Autumno. Hieme. N. and S. Car. et N. York. Dr. Sartwell.

112. P. (Inodermei) chartaceus, Berk. and Curt.;—rigido-membranaceous ambiens e resupinato utrinque reflexus; pileo leviter zonato albido sericeo; poris sistotrematoideis pallidis. Subter ram. et trunc. dejectis Liriodendri. Vere. Hillsborough, N. Car.

Effused for several feet and completely surrounding the smaller branches, broadly reflexed; margin membranaceous but rigid; pores about $\frac{1}{30}$ in. broad, breaking into obtuse lamellar processes, extending to the margin where they are shallow and more distant.—Allied to *P. pinsitus*, of which we at first thought it was a variety, but differing in its nearly smooth pileus and the singularly decomposed pores.

113. P. niger, Berk.—Ad trunc. Querc. deject. cariosum. Hieme. S. Car. (Ravenel.) Ohio, (Lea.)

114. P. Cremor, Berk. and Curt.; resupinatus albus; margine obsoleto, poris parvis subrotundis, dissepimentis crassis, acie obtusissima.—Ad ram. querc. dejectos. Vere. Society Hill.

Allied to *P. vulgaris*, but differing in its thick dissepiments and the obtuse edge of the pores.

115. P. salmonicolor, Berk. and Curt.;—resupinatus crassus, mycelio mucedineo albo, poris rotundis rubellis demum elongatis purpureo-fuscis.—Ad lignum pineum adustum. Aestate. Santee Canal. Ravenel.

Effused, several inches broad, margin thin, centre thick, of a rich salmon color, at length brown. Pores small, at length torn and angular. When fresh this appears to be very tender and easily injured, in which state it becomes dark purple brown, with a resinous aspect. Not closely allied to any described species. Its nearest affinities are with *P. purpureus*, Fr. and *P. rhodellus*, Fr., or better with *P. carneofuscus*, P.

116. Daedalea cinerea, Fr.—Ad trunc. dejectum. Autumno. R. Island; Mr. Bennett.

117. D. sæpium, Berk.—Ad lignum Quercûs, Taxodii, &c. Autumno. Hieme. Ohio (Lea), R. Island (Mr. Bennett), N. and S. Carolina.

118. Lenzites cratægi, Berk.—Ad Liquidambar. Society Hill, S. C.

119. Favolus curtipes, Berk. and Curt.;—pileo tenui reniformi carnoso-rigido glabro; stipite brevissimo disciformi; poris mediis sinuatis plicatis.—Ad trunc. mort. Autumno. Ravenel.

Cap 2 in. broad, 1½ long, very smooth, rigid, and tawny when dry. Pores $\frac{1}{30}$ in. broad, pale, undulated and crisped; edge white. An extremely pretty species resembling *F. cucullatus*, Mont.; but the pores are less rigid and smaller, the substance more fleshy.

120. Glœoporus conchoides, Mont.—Ad trunc. prostratum. Society Hill, S. Car.

121. Merulius Corium, Fr.—Ad cort. Quercûs, Castaneæ, &c. Autumno, Vere. S. Car.

122. M. incrassatus, Berk. and Curt.;—effusus resupinatus, crassus margine breviter reflexo; plicis poriformibus.—Ad lign. pineum cariosum. Society Hill, S. Car.

Effused for several inches, resupinate, with the margin shortly reflexed, dirty white and slightly silky. Substance thick, fleshy. Folds forming small brownish pores. Allied to *M. tremellosus*.

123. Porothelium Friesii, Mont.—Ad corticem Juniperi. Hieme. Santee Canal; Ravenel.

ARRHYTIDIA, nov. gen.—Hymenophorum a mycelio mucedineo contexto formatum, marginatum, tectum hymenio ceraceo molli lævi sine plicis. Sporæ oblongæ.

124. Arrhytidia flava, Berk. and Curt.—Ad ramos dejectos Pini. Society Hill, S. Car.

Forming little scattered, sometimes confluent patches, ⅛ in. broad, consisting of a white mycelium which forms a distinct border to the smooth orange yellow hymenium; sometimes the border is double. Spores oblong, fixed obliquely at the base.

This has just the habit of *Psilopezia*, but is without *Asci*. It is a distinctly bordered, mostly pezizæform *Merulius*, destitute of folds.

125. Hydnum velutinum, Fr.—Ad terram in sylvis. Hillsborough, N. Car.

126. H. graveolens, Delastre.—Ad basin caudicum in sylvis. Aestate. Society Hill, S. Car.

127. H. pulcherrimum, Berk. and Curt.;—dimidiatum crassum lobatum spongiosum carnoso-fibrosum hirsùtum intus zonatum, margine tenui; aculeis breviusculis subulatis. Ad truncos prostratos in paludosis. Aestate, Autumno. Santee Canal, (Mr. Ravenel,) and Society Hill, S. Car.

Pilei very white becoming pale tawny, subimbricated, 3–6 in. broad, 2–3 long, 1–2 thick, of a soft spongy consistence, clothed with copious stiff down which is more or less matted with age, sometimes as if gummed together. Substance slightly zoned. Teeth 1–2 lines long, tawny.—This splendid species is closely allied to *H. septentrionale*, but is smaller, far less imbricated, and clothed with much stiffer hairs. The general texture is precisely that of *Pol. hispidus.*

128. H. pithyophilum, Berk. and Curt.;—resupinatum effusum, subiculo tenuissimo farinaceo-byssoideo; aculeis ochraceis compressis apice dentato-laceris.—Ad ram. dejectos (lign. et cort.) pineos, Autumno, Hieme. Society Hill, S. C.

Forming confluent patches several inches in length. Subiculum extremely thin, sometimes farinaceous, sometimes finely byssoid, white. Teeth pale ochraceous 1 line long, more or less toothed or jagged at the apex.—Resembling resupinate states of *H. ochraceum*, but differing both in the subiculum and teeth.

129. H. ciliolatum, Berk. and Curt.;—resupinatum orbiculare tenue vix a matrice solubile; aculeis brevibus compressis floccoso-ciliolatis.—Ad ramos dejectos (lign. et cort.) Quercus et Liriodendri (?). Autumno. Society Hill.

Forming small orbicular patches, an inch or two in diameter, nearly white with a pale ochraceous tint, thin, margin minutely byssoid, sometimes slightly raised. Teeth short, minutely ciliated with fine flocci, extending to the very margin where they are merely little downy fascicles.—Resembling resupinate forms of *H. ochraceum*, but differing widely in the nature of the teeth.

130. H. PLUMOSUM, Duby.—In rimis cort. crassæ Pini. Hieme. Society Hill.

ART. XVIII.—*Experimental Researches in Electricity.—Twenty-third Series;* by MICHAEL FARADAY, Esq., D.C.L., F.R.S., etc.*

§ 29. *On the polar or other condition of diamagnetic bodies.*

2640. FOUR years ago I suggested that all the phenomena presented by diamagnetic bodies, when subjected to the forces in the magnetic field, might be accounted for by assuming that they then possessed a polarity the same in kind as, but the reverse in direction of, that acquired by iron, nickel and ordinary magnetic bodies under the same circumstances (2429. 2430.). This view was received so favorably by Plücker, Reich and others, and above all by W. Weber,† that I had great hopes it would be confirmed; and though certain experiments of my own (2497.) did not increase that hope, still my desire and expectation were in that direction.

2641. Whether bismuth, copper, phosphorus, &c., when in the magnetic field, are polar or not, is however an exceedingly important question; and very essential and great differences in the mode of action of these bodies under the one view or the other, must be conceived to exist. I found that in every endeavor to proceed by induction of experiment from that which is known in this department of science to the unknown, so much uncertainty, hesitation and discomfort arose from the unsettled state of my mind on this point, that I determined, if possible, to arrive at some experimental proof either one way or the other. This was the more needful, because of the conclusion in the affirmative to which Weber had come in his very philosophical paper; and so important do I think it for the progress of science, that in those imperfectly developed regions of knowledge, which form its boundaries, our conclusions and deductions should not go far beyond, or at all events not aside from the results of experiment (except as suppositions), that I do not hesitate to lay my present labors, though they arrive at a negative result, before the Royal Society.

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* From the Trans. Roy. Soc., London, Part I, for 1850.—Read March 7 and 14, 1850.

† Poggendorff's Annalen, January 7, 1848, or Taylor's Scientific Memoirs, v, p. 477.

2642. It appeared to me that many of the results which had been supposed to indicate a polar condition, were only consequences of the law that diamagnetic bodies tend to go from stronger to weaker places of action (2418.); others again appeared to have their origin in induced currents (26. 2338.); and further consideration seemed to indicate that the differences between these modes of action and that of a real polarity, whether magnetic or diamagnetic, might serve as a foundation on which to base a mode of investigation, and also to construct an apparatus that might give useful conclusions and results in respect of this inquiry. For, if the polarity exists it must be in the particles and for the time permanent, and therefore distinguishable from the momentary polarity of the mass due to induced temporary currents; and it must also be distinguishable from ordinary magnetic polarity by its contrary direction.

2643. A straight wooden lever, 2 feet in length, was fixed by an axis at one end, and by means of a crank and wheel made to vibrate in a horizontal plane, so that its free extremity passed to and fro through about 2 inches. Cylinders or cores of metal or other substances, 5½ inches long and three-quarters of an inch diameter, were fixed in succession to the end of a brass rod 2 feet long, which itself was attached at the other end to the moving extremity of the lever, so that the cylinders could be moved to and fro in the direction of their length through the space of 2 inches. A large cylinder electro-magnet was also prepared (2191.), the iron core of which was 21 inches long and 1·7 inch in diameter; but one end of this core was made smaller for the length of 1 inch, being in that part only 1 inch in diameter.

2644. On to this reduced part was fixed a hollow helix consisting of 516 feet of fine covered copper wire: it was 3 inches long, 2 inches external diameter, and 1 inch internal diameter: when in its place, 1 inch of the central space was occupied by the reduced end of the electro-magnet core which carried it; and the magnet and helix were both placed concentric with the metal cylinder above mentioned, and at such a distance that the latter, in its motion, would move within the helix in the direction of its axis, approaching to and receding from the electro-magnet in rapid or slow succession. The least and greatest distances of the moving cylinder from the magnet during the journey were one-eighth of an inch and 2·2 inches. The object of course was to observe any influence upon the experimental helix of fine wire which the metal cylinders might exert, either whilst moving to or from the magnet, or at different distances from it.*

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* It is very probable that if the metals were made into cylinders, shorter but of larger diameter than those described above, and used with a corresponding wider helix, better results than those I have obtained would be acquired.

2645. The extremities of the experimental helix wire were connected with a very delicate galvanometer, placed 18 or 20 feet from the machine, so as to be unaffected directly by the electro-magnet; but a commutator was interposed between them. This commutator was moved by the wooden lever (2643.), and as the electric currents which would arrive at it from the experimental helix, in a complete cycle of motion or to and fro action of the metal cylinder (2643.), would consist of two contrary portions, so the office of this commutator was, sometimes to take up these portions in succession and send them on in one consistent current to the galvanometer, and at other times to oppose them and to neutralize their result; and therefore it was made adjustible, so as to change at any period of the time or part of the motion.

2646. With such an arrangement as this, it is known that, however powerful the magnet, and however delicate the other parts of the apparatus, no effect will be produced at the galvanometer as long as the magnet does not change in force, or in its action upon neighboring bodies, or in its distance from, or relation to, the experimental helix; but the introduction of a piece of iron into the helix, or anything else that can influence or be influenced by the magnet, can, or ought to, show a corresponding influence upon the helix and galvanometer. My apparatus I should imagine, indeed, to be almost the same in principle and practice as that of M. Weber (2640.), except that it gives me contrary results.

2647. But to obtain correct conclusions, it is most essential that extreme precaution should be taken in relation to many points which at first may seem unimportant. All parts of the apparatus should have perfect steadiness, and be fixed almost with the care due to an astronomical instrument; for any motion of any portion of it, is, from the construction, sure to synchronize with the motion of the commutator; and portions of effect, inconceivably small, are then gathered up and made manifest as a whole at the galvanometer; and thus, without care, errors might be taken for real and correct results. Therefore, in my arrangements, the machine (2643, &c.), the magnet and helix, and the galvanometer stood upon separate tables, and these again upon a stone floor laid upon the earth; and the table carrying the machine was carefully strutted to neighboring stone-work.

2648. Again, the apparatus should itself be perfectly firm and without shake in its motion, and yet easy and free. No iron should be employed in any of the moving parts. I have springs to receive and convert a portion of the momentum of the whole at the end of the to and fro journey; but it is essential that these should be of hammered brass or copper.

2649. It is absolutely necessary that the cylinder or core in its motion should not in the least degree disturb or shake the experimental helix and the magnet. Such a shake may easily take place, and yet (without much experience) not be perceived. It is important to have the cores of such bodies as bismuth, phosphorus, copper, &c., as large as may be, but I have not found it safe to have less than one-eighth of an inch of space between them and the interior of the experimental helix. In order to float, as it were, the core in the air, it is convenient to suspend it in the bight or turn of a fine copper wire passing once round it, the ends of which rise up, and are made fast to two fixed points at equal heights but wide apart, so that the wire has a V form. This suspension keeps the core parallel to itself in every part of its motion.

2650. The magnet, when excited, is urged by an electric current from five pairs of Grove's plates, and is then very powerful. When the battery is not connected with it, it still remains a magnet of feeble power, and when thus employed may be referred to as in the *residual state*. If employed in the residual state, its power may for the time be considered constant, and the experimental helix may at any moment be connected with the galvanometer without any current appearing there. But if the magnet be employed in the excited state, certain important precautions are necessary; for upon connecting the magnet with the battery and then connecting the experimental helix with the galvanometer, a current will appear at the latter, which will, in certain cases, continue for a minute or more, and which has the appearance of being derived at once from that of the battery. It is not so produced, however, but is due to the *time* occupied by the iron core in attaining its maximum magnetic condition (2170. 2332.), during the whole of which it continues to act upon the experimental helix, producing a current in it. This time varies with several circumstances, and in the same electro-magnet varies especially with the period during which the magnet has been out of use. When first employed, after two or three days' rest, it will amount to eighty or ninety seconds, or more. On breaking battery contact and immediately renewing it, the effect will be repeated, but occupy only twenty or thirty seconds. On a third intermission and renewal of the current, it will appear for a still shorter period; and when the magnet has been used at short intervals for some time, it seems capable of receiving its maximum power almost at once. In every experiment it is necessary to wait until the effect is shown by the galvanometer to be over; otherwise the last remains of such an effect might be mistaken for a result of polarity, or some peculiar action of the bismuth or other body under investigation.

2651. The galvanometer employed was made by Ruhmkorff and was very sensible. The needles were strengthened in their action and rendered so nearly equal, that a single vibration to the right or the left occupied from sixteen to twenty seconds. When experimenting with such bodies as bismuth or phosphorus, the place of the needle was observed through a lens. The perfect communication in all parts of the circuit was continually ascertained by a feeble thermo-electric pair, warmed by the fingers. This was done also for every position of the commutator, where the film of oxyd formed on any part by two or three days' rest was quite sufficient to intercept a feèble current.

2652. In order to bring the phenomena afforded by magnetic and diamagnetic bodies into direct relation, I have not so much noted the currents produced in the experimental helix, as the effects obtained at the galvanometer. It is to be understood, that the standard of deviation, as to direction, has always been that produced by an iron wire moving in the same direction at the experimental helix, and with the same condition of the commutator and connecting wires, as the piece of bismuth or other body whose effects were to be observed and compared.

2653. A thin glass tube, of the given size (2643.), 5½ by ⅜ inches, was filled with a saturated solution of protosulphate of iron, and employed as the experimental core: the velocity given to the machine at this and all average times of experiment was such as to cause five or six approaches and withdrawals of the core in one second; yet the solution produced no sensible indication at the galvanometer. A piece of magnetic glass tube (2354.), and a core of foolscap paper, magnetic between the poles of the electro-magnet, were equally inefficient. A tube filled with small crystals of protosulphate of iron caused the needle to move about 2°, and cores formed out of single large crystals, or symmetric groups of crystals of sulphate of iron, produced the same effect. Red oxyd of iron (colcothar) produced the least possible effect. Iron scales and metallic iron (the latter as a thin wire) produced large effects.

2654. Whenever the needle moved, it was consistent in its direction with the effect of a magnetic body; but in many cases, with known magnetic bodies, the motion was little or none. This proves that such an arrangement is by no means so good a test of magnetic polarity as the use of a simple or an astatic needle. This deficiency of power in that respect does not interfere with its ability to search into the nature of the phenomena that appear in the experiments of Weber, Reich and others.

2655. Other metals than iron were now employed and with perfect success. If they were magnetic, as nickel and cobalt, the deflection was in the same direction as for iron. When the metals were diamagnetic, the deflection was in the contrary direction; and for some of the metals, as copper, silver and gold, it amounted to 60° or 70°, which was permanently sustained as long as the machine continued to work. But the deflection was not the greatest for the most diamagnetic substances, as bismuth, or antimony, or phosphorus; on the contrary, I have not been able to assure myself, up to this time, that these three bodies can produce any effect. Thus far the effect has been proportionate to the *conducting power* of the substance for electricity. Gold, silver and copper have produced large deflections, lead and tin less. Platina very little. Bismuth and antimony none.

2656. Hence there was every reason to believe that the effects were produced by the currents induced in the mass of the moving metals, and not by any polarity of their particles. I proceeded therefore to test this idea by different conditions of the cores and the apparatus.

2657. In the first place, if produced by induced currents, the great proportion of these would exist in the part of the core near to the dominant magnet, and but little in the more distant parts; whereas in a substance like iron, the polarity which the whole assumes makes length a more important element. I therefore shortened the core of copper from 5½ inches (2643.) to 2 inches, and found the effect not sensibly diminished; even when 1 inch long it was little less than before. On the contrary, when a fine iron wire, 5½ inches in length, was used as core, its effects were strong; when the length was reduced to 2 inches, they were greatly diminished; and again, with a length of 1 inch, still further greatly reduced. It is not difficult to construct a core of copper, with a fine iron wire in its axis, so that when above a certain length it should produce the effects of iron, and beneath that length the effects of copper.

2658. In the next place, if the effect were produced by induced currents in the mass (2642.), division of the mass would stop these currents and so alter the effect; whereas if produced by a true diamagnetic polarity, division of the mass would not affect the polarity seriously, or in its essential nature (2430.). Some copper filings were therefore digested for a few days in dilute sulphuric acid to remove any adhering iron, then well washed and dried, and afterwards warmed and stirred in the air, until it was seen by the orange color that a very thin film of oxyd had formed upon them: they were finally introduced into a glass tube (2653.) and employed as a core. It produced no effect whatever, but was now as inactive as bismuth.

2659. The copper may however be divided so as either to interfere with the assumed currents or not, at pleasure. Fine copper wire was cut up into lengths of 5½ inches, and as many of these associated together as would form a compact cylinder three-quarters of an inch in diameter (2643.); it produced no effect at the galvanometer. Another copper core was prepared by associating together many discs of thin copper plate, three-quarters of an inch in diameter, and this affected the galvanometer, holding its needle 25° or 30° from zero.

2660. I made a solid helix cylinder, three-quarters of an inch in diameter and 2 inches long, of covered copper wire, one-sixteenth of an inch thick, and employed this as the experimental core. When the two ends of its wire were unconnected, there was no effect upon the experimental helix, and consequently none at the galvanometer; but when the ends were soldered together, the needle was well affected. In the first condition, the currents, which tended to be formed in the mass of moving metal, could not exist because the metal circuit was interrupted; in the second they could, because the circuit was not interrupted; and such division as remained did not interfere to prevent the currents.

2661. The same results were obtained with other metals. A core cylinder of gold, made of half-sovereigns, was very powerful in its effect on the galvanometer. A cylinder of silver, made of sixpenny pieces, was very effectual; but a cylinder made of precipitated silver, pressed into a glass tube as closely as possible, gave no indications of action whatever. The same results were obtained with disc cylinders of tin and lead, the effects being proportionate to the condition of tin and lead as bad conductors. (2655.)

2662. When iron was divided, the effects were exactly the reverse in kind. It was necessary to use a much coarser galvanometer and apparatus for the purpose; but that being done, the employment of a solid iron core, and of another of the same size or weight formed of lengths of fine iron wire (2659.), showed that the division had occasioned no inferiority in the latter. The excellent experimental researches of Dove* on the electricity of induction, will show that this ought to be the case.

2663. Hence the result of division in the diamagnetic metals is altogether of a nature to confirm the conclusion, that the effects produced by them are due to induced currents moving through their masses, and not to any polarity correspondent in its general nature (though opposed in its direction) to that of iron.

2664. In the third place (2656.), another and very important distinction in the actions of a diamagnetic metal may be experimentally established according as they may be due either to a true polarity, or merely to the presence of temporary induced currents; and as for the consideration of this point diamagnetic and magnetic polarity are the same, the point may best be considered, at present, in relation to iron.

2665. If a core of any kind be advanced towards the dominant magnet and withdrawn from it by a motion of uniform velocity, then a complete journey or *to* and *from* action might be divided into four parts; the *to*, the *stop* after it; the *from*, and the *stop* succeeding that. If a core of iron make this journey, its end towards the dominant magnet becomes a pole, rising in force until at the nearest distance, and falling in force until at the greatest distance. Both this effect and its *progression* inwards and outwards, cause currents to be induced in the surrounding helix, and these currents are in one direction as the core advances, and in the contrary direction as it recedes. In reality, however, the iron does not travel with a constant velocity; for, because of the communication of motion from a revolving crank at the machine (2643.), it, in the *to* part of the journey, gradually rises from a state of rest to a maximum velocity, which is half-way, and then as gradually sinks to rest again near the magnet:—and the *from* part of the journey undergoes the same variations. Now as the maximum effect upon the surrounding experimental helix depends upon the velocity conjointly with the intensity of the magnetic force in the end of the core, it is evident that it will not occur with the maximum velocity, which is in the middle of the *to* or *from* motion; nor at the *stop* nearest to the dominant magnet, where the core end has greatest magnetic force, but somewhere between the two. Nevertheless, during the *whole* of the advance, the core will cause a current in the experimental helix in one direction, and during the whole of the recession it will cause a current in the other direction.

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* Taylor's Scientific Memoirs, v, p. 129. I do not see a date to the paper.

2666. If diamagnetic bodies, under the influence of the dominant magnet, assume also a polar state, the difference between them and iron being only that the poles of like names or forces are changed in place (2429. 2430.), then the same kind of action as that described for iron would occur with them; the only difference being, that the two currents produced would be in the reverse direction to those produced by iron.

2667. If a commutator, therefore, were to be arranged to gather up these currents, either in the one case or the other, and send them on to the galvanometer in one consistent current, it should change at the moments of the two *stops* (2665.), and then would perform such duty perfectly. If, on the other hand, the commutator should change at the times of maximum velocity or maximum intensity, or at two other times equidistant either from the one *stop* or from the other, then the parts of the opposite currents intercepted between the changes would exactly neutralize each other, and no final current would be sent on to the galvanometer.

2668. Now the action of the iron is, by experiment, of this nature. If an iron wire be simply introduced or taken out of the experimental helix with different conditions of the commutator, the results are exactly those which have been stated. If the machine be worked with an iron wire core, the commutator changing at the stops (2665.), then the current gathered up and sent on to the galvanometer is a maximum; if the commutator change at the moments of maximum velocity, or at any other pair of moments equidistant from the one stop or the other, then the current at the commutator is a minimum, or 0.

2669. There are two or three precautions which are necessary to the production of a pure result of this kind. In the first place, the iron ought to be soft and not previously in a magnetic state. In the next, an effect of the following kind has to be guarded against. If the iron core be away from the dominant magnet at the beginning of an experiment, then, on working the machine, the galvanometer will be seen to move in one direction for a few moments, and afterwards, notwithstanding the continued action of the machine, will return and gradually take up its place at 0°. If the iron core be at its shortest distance from the dominant magnet at the beginning of the experiment, then the galvanometer needle will move in the contrary direction to that which it took before, but will again settle at 0°. These effects are due to the circumstance, that, when the iron is away from the dominant magnet, it is not in so strong a magnetic state, and when at the nearest to it is in a stronger state, than the *mean* or *average state*, which it acquires during the continuance of an experiment; and that in rising or falling to this average state, it produces two currents in contrary directions, which are made manifest in the experiments described. These existing only for the first moments, do, in their effects at the galvanometer, then appear, producing a vibration which gradually passes away.

2670. One other precaution I ought to specify. Unless the commutator changes accurately at the given points of the journey, a little effect is gathered up at each change, and may give a permanent deflection of the needle in one direction or the other. The tongues of my commutator, being at right angles to the direction of motion and somewhat flexible, dragged a little in the *to* and *from* parts of the journey: in doing this they approximated, though only in a small degree, to that which is the best condition of the commutator for gathering up (and not opposing) the currents; and a deflection to the right or left appeared (2677.). Upon discovering the cause and stiffening the tongues so as to prevent their flexure, the effect disappeared, and the iron was perfectly inactive.

2671. Such therefore are the results with an iron core, and such would be the effects with a copper or bismuth core if they acted by a diamagnetic polarity. Let us now consider what the consequences would be if a copper or bismuth core were to act by currents, induced for the time, in its moving mass, and of the nature of those suspected (2642.). If the copper cylinder moved with uniform velocity (2665.), then currents would exist in it, parallel to its circumference, during the whole time of its motion;

and these would be at their maximum force just before and just after the *to* or inner stop, for then the copper would be in the most intense parts of the magnetic field. The rising current of the copper core for the *in* portion of the journey would produce a current in one direction in the experimental helix, the stopping of the copper and consequent falling of its current would produce in the experimental helix a current contrary to the former; the first instant of motion *outwards* in the core would produce a maximum current in it contrary to its former current, and producing in the experimental helix its inductive result, being a current the same as the last there produced; and then, as the core retreated, its current would fall, and in so doing and by its final stop, would produce a fourth current in the experimental helix, in the same direction as the first.

2672. The four currents produced in the experimental helix alternate by twos, *i. e.* those produced by the falling of the first current in the core and the rising of the second and contrary current, are in one direction. They occur at the instant before and after the stop at the magnet, *i. e.* from the moment of maximum current (in the core) before, to the moment of maximum current after, the stop; and if that stop is momentary, they exist only for that moment, and should during that brief time be gathered up by the commutator. Those produced in the experimental helix during the falling of the second current in the core and the rising of a third current (identical with the first) in the return of the core to the magnet, are also the same in direction, and continue from the beginning of the retreat to the end of the advance (or from maximum to maximum) of the core currents, *i. e.* for almost the whole of the core journey; and these, by its change at the maximum moments, the commutator should take up and send on to the galvanometer.

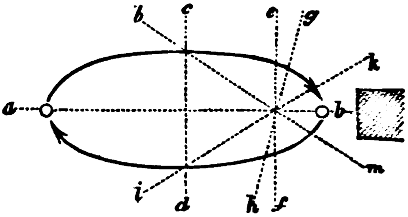
2673. The motion however of the core is not uniform in velocity, and so, sudden in its change of direction, but, as before said (2665.), is at a maximum as respects velocity in the middle of its approach to and retreat from the dominant magnet; and hence a very important advantage. For its stop may be said to commence immediately after the occurrence of the maximum velocity; and if the lines of magnetic force were equal in position and power there to what they are nearer to the magnet, the contrary currents in the experimental helix would commence at those points of the journey; but, as the core is entering into a more intense part of the field, the current in it still rises though the velocity diminishes, and the consequence is, that the maximum current in it neither occurs at the place of greatest velocity, nor of greatest force, but at a point between the two. This is true both as regards the approach and the recession of the core, the two maxima of the currents occurring at points equidistant from the place of rest near the dominant magnet.

2674. It is therefore at these two points that the commutator should change, if adjusted to produce the greatest effect at the galvanometer by the currents excited in the experimental helix, through the influence of, or in connection with, currents of induction produced in the core; and experiment fully justifies this conclusion. If the length of the journey from the stop out to the stop in, which is 2 inches (2643. 2644.), be divided in 100 parts, and the dominant magnet be supposed to be on the right hand, then such an expression as the following, 50|50, may represent the place where the commutator changes, which in this illustration would be midway in the to and from motion, or at the places of greatest velocity.

2675. Upon trial of various adjustments of the commutator, I have found that from 77|23 to 88|12, gave the best result with a copper core. On the whole, and after many experiments, I conclude that with the given strength of electro-magnet, distance of the experimental core when at the nearest from the magnet, length of the whole journey, and average velocity of the machine, 86|14 may represent the points where the induced currents in the core are at a maximum and where the commutator ought to change.

2676. From what has been said before (2667.), it will be seen that both in theory and experiment these are the points in which the effect of any polarity, magnetic or diamagnetic, would be absolutely nothing. Hence the power of submitting by this machine metals and other bodies to experiment, and of eliminating the effects of magnetic polarity, of diamagnetic polarity, and of inductive action, the one from the others: for either by the commutator or by the direction of the polarity, they can be separated; and further, they can also be combined in various ways for the purpose of elucidating their joint and separate action.

2677. For let the arrows in the diagram represent the to and from journey, and the intersections of the lines, *a*, *b*, or *c*, *d*, &c., the periods in the journey when the commutator changes (in which case *c*, *d* will correspond to 50|50, and *e*, *f* to 86|14), then *a*, *b* will represent the condition of the commutator for the maximum effect of iron or any other polar body. If the line *a*, *b*, be gradually revolved until parallel to *c*, *d*, it will in every position indicate points of commutator change, which will give the iron effect at the galvanometer by a deflection of the needle always in the same direction; it is only when the ends *a* and *b* have passed the points *c* and *d*, either above or below, that the direction of the deflection will change



for iron. But the line *a*, *b* indicates those points for the commutator with which no effect will be produced on the galvanometer by the induction of *currents* in the mass of the core. If the line be inclined in one direction, as *i*, *k*, then these currents will produce a deflection at the galvanometer on one side; if it be inclined in the other direction, as *l*, *m*, then the deflection will be on the other side. Therefore the effects of these induced currents may be either combined with, or opposed to, the effects of a polarity, whether it be magnetic or diamagnetic.

2678. All the metals before mentioned (2655.), namely, gold, silver, copper, tin, lead, platina, antimony and bismuth, were submitted to the power of the electro-magnet under the best adjustment (2675.) of the commutator. The effects were stronger than before, being now at a maximum, but in the same order; as regarded antimony and bismuth, they were very small, amounting to not more than half a degree, and may very probably have been due to a remainder of irregular action in some part of the apparatus. All the experiments with the divided cores (2658, &c.) were repeated with the same results as before. Phosphorus, sulphur and gutta percha did not, either in this or in the former state of the commutator, give any indication of effect at the galvanometer.

2679. As an illustration of the manner in which this position of the commutator caused a separation of the effects of copper and iron, I had prepared a copper cylinder core 2 inches in length having an iron wire in its axis, and this being employed in the apparatus gave the pure effect of the copper with its induced currents. Yet this core, as a whole, was highly magnetic to an ordinary test-needle; and when the two changes of the commutator were not equidistant from the one stop or the other (2670. 2677.), the iron effect came out powerfully, overruling the former and producing very strong contrary deflections at the needle. The platinum core which I have used is an imperfect cylinder, 2 inches long and 0·62 of an inch thick: it points magnetically between the poles of a horseshoe electro-magnet (2381.), making a vibration in less than a second, but with the above condition of the commutator (2675.) gives 4° of deflection due to the induced currents the magnetic effect being annulled or thrown out.

2680. Some of the combined effects produced by oblique position of the commutator points were worked out in confirmation of the former conclusions (2677.). When the commutator was so adjusted as to combine any polar power which the bismuth, as a diamagnetic body, might possess, with any conducting power which would permit the formation of currents by induction in its mass (2676.), still the effects were so minute and uncertain as to oblige me to say that, experimentally, it is without either polar or inductive action.

2681. There is another distinction which may usefully be established between the effects of a true sustainable polarity, either magnetic or diamagnetic, and those of the transient induced currents dependent upon *time*. If we consider the resistance in the circuit, which includes the experimental helix and the galvanometer coil, as nothing, then a magnetic pole of constant strength passed a certain distance into the helix, would produce the same amount of current electricity in it, whether the pole were moved into its place by a quick or slow motion. Or if the iron core be used (2668.) the same result is produced, provided, in any alternating action, the core is left long enough at the extremities of its journey to acquire, either in its quick or slow alternation, the same state. This I found to be the fact when no commutator nor dominant magnet was used; a single insertion of a weak magnetic pole gave the same deflection, whether introduced quickly or slowly; and when the residual dominant magnet, an iron wire core, and the commutator in its position, *a*, *b* were (2677.) used, four journeys to and from produced the *same* effect at the galvanometer when the velocities were as 1 : 5 or even as 1 : 10.

2682. When a copper, silver, or gold core is employed in place of the iron, the effect is very different. There is no reason to doubt, that as regards the core itself the same amount of electricity is thrown into the form of induced circulating currents within it, by a journey to or from, whether that journey is performed quickly or slowly: the above experiment (2681.) in fact confirms such a conclusion. But the effect which is produced upon the experimental helix is not proportionate to the whole amount of these currents, but to the maximum intensities to which they rise. When the core moves slowly, this intensity is small; when it moves rapidly, it is great, and necessarily so, for the same current of electricity has to travel in the two differing periods of time occupied by the journeys. Hence the quickly moving core should produce a far higher effect on the experimental helix than the slowly moving core: and this also I found to be the fact.

2683. The short copper core was adjusted to the apparatus, and the machine worked with its average velocity until forty journeys to and from had been completed; the galvanometer needle passed 39° west. Then the machine was worked with a greater rapidity, also for forty journeys, and the needle passed through 80° or more west; finally, being worked at a slow rate for the same number of journeys, the needle went through only 21° west. The extreme velocities in this experiment were probably as 1 : 6; the time in the longest case was considerably less than that of one vibration of the needle (2651.), so that I believe all the force in the slowest case was collected. The needle is very little influenced by the swing or momentum of its parts, because of the deadening effect of the copper plate beneath it, and, except to return to zero, moves very little after the motion of the apparatus ceases. A silver core produced the same results.

2684. These effects of induced currents have a relation to the phenomena of revulsion which I formerly described (2310. 2315. 2338.), being the same in their exciting cause and principles of action, and so the two sets of phenomena confirm and illustrate each other. That the revulsive phenomena are produced by induced currents, has been shown before (2327. 2329. 2336. 2339.); the only difference is, that with them the induced currents were produced by exalting the force of a magnet placed at a fixed distance from the affected metal; whilst in the present phenomena, the force of the magnet does not change, but its distance from the piece of metal does.

2685. So also the same circumstances which affect the phenomena here affect the revulsive phenomena. A plate of metal will, as a whole, be well-revulsed; but if it be divided across the course of the induced currents it is not then affected (2529.). A ring helix of copper wire, if the extremities be unconnected, will not exhibit the phenomena, but if they be connected then it presents them (2660.).

2686. On the whole, the revulsive phenomena are a far better test and indication of these currents than the present effects; especially if advantage be taken of the division of the mass into plates, so as to be analogous, or rather superior, in their action to the disc cylinder cores (2659. 2661.). Platinum, palladium and lead in leaf or foil, if cut or folded into squares half an inch in the side, and then packed regularly together, will show the phenomena of revulsion very well; and that according to the direction of the leaves, and not of the external form. Gold, silver, tin and copper have the revulsive effects thus greatly exalted. Antimony, as I have already shown, exhibits the effect well (2514. 2519.). Both it and bismuth can be made to give evidence of the induced currents produced in them when they are used in thin plates, either single or associated, although, to avoid the influence of the diamagnetic force, a little attention is required to the moments of making and breaking contact between the voltaic battery and the electro-magnet.

2687. Copper, when thus divided into plates, had its revulsive phenomena raised to a degree that I had not before observed. A piece of copper foil was annealed and tarnished by heat, and then folded up into a small square block, half an inch in the side and a quarter of an inch thick, containing seventy-two folds of the metal. This block was suspended by a silk film as before (2248.), and whilst at an angle of 30° or thereabouts with the equatorial line (2252.), the electro-magnet was excited; it immediately advanced or turned until the angle was about 45° or 50°, and then stood still. Upon the interruption of the electric current at the magnet the revulsion came on very strongly, and the block turned back again, passed the equatorial line, and proceeded on until it formed an angle of 50° or 60° on the other side; but instead of continuing to revolve in that direction as before (2315.), it then returned on its course, again passed the equatorial line, and almost reached the axial position before it stood still. In fact, as a mass, it vibrated to and fro about the equatorial line.

2688. This however is a simple result of the principles of action formerly developed (2329. 2336.). The revulsion is due to the production of induced currents in the suspended mass during the falling of the magnetism of the electro-magnet; and the effect of the action is to bring the axis of these induced currents parallel to the axis of force in the magnetic field. Consequently, if the time of the fall of magnetic force, and therefore of the currents dependent thereon, be greater than the time occupied by the revulsion of the copper block as far as the equatorial line, any further motion of it by momentum will be counteracted by a contrary force; and if this force be strong enough the block will return. The conducting power of the copper and its division into laminæ, tend to set up these currents very readily and with extra power; and the very power which they possess tends to make the time of a vibration so short, that two or even three vibrations can occur before the force of the electro-magnet has ceased to fall any further. The effect of *time*, both in the rising and falling of power, has been referred to on many former occasions (2170. 2650.), and is very beautifully seen here.

2689. Returning to the subject of the assumed polarity of bismuth, I may and ought to refer to an experiment made by Reich, and described by Weber,* which, if I understand the instruction aright, is as follows: a strong horseshoe magnet is laid upon a table in such a position that the line joining its two poles is perpendicular to the magnetic meridian and to be considered as prolonged on one side; in that line, and near the magnet, is to be placed a small powerful magnetic needle, suspended by cocoon silk, and on the other side of it, the pole of a bar magnet, in such a position and so near, as exactly to counteract the effect of the horseshoe magnet, and leave the needle to point exactly as if both magnets were away. Then a mass of bismuth being placed between the poles of the horseshoe magnet is said to react upon the small magnet needle, causing its deflection in a particular direction, and this is supposed to indicate the polarity of the bismuth under the circumstances, as it has no such action when the magnets are away. A piece of iron in place of the bismuth produces the contrary deflection of the needle.

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* Taylor's Scientific Memoirs, v, p. 480.

2690. I have repeated this experiment most anxiously and carefully, but have never obtained the slightest trace of action with the bismuth. I have obtained action with the iron; but in those cases the action was far less than if the iron were applied outside between the horseshoe magnet and the needle, or to the needle alone, the magnets being entirely away. On using a garnet, or a weak magnetic substance of any kind, I cannot find that the arrangement is at all comparable for readiness of indication or delicacy, with the use of a common or an astatic needle, and therefore I do not understand how it could become a test of the polarity of bismuth when these fail to show it. Still I may have made some mistake; but neither by close reference to the description, nor to the principles of polar action, can I discover where.

2691. There is an experiment which Plücker described to me, and which at first seems to indicate strongly the polarity of bismuth. If a bar of bismuth (or phosphorus) be suspended horizontally between the poles of the electro-magnet, it will go to the equatorial position with a certain force, passing, as I have said, from stronger to weaker places of action (2267.). If a bar of iron of the same size be fixed in the equatorial position a little below the plane in which the diamagnetic bar is moving, the latter will proceed to the equatorial position with much greater force than before, and this is considered as due to the circumstance, that, on the side where the iron has N polarity, the diamagnetic body has S polarity, and that on the other side the S polarity of the iron and the N polarity of the bismuth also coincide.

2692. It is however very evident that the lines of magnetic force have been altered sufficiently in their intensity of direction, by the presence of the iron, to account fully for the increased effect. For, consider the bar as just leaving the axial position and going to the equatorial position; at the moment of starting its extremities are in places of stronger magnetic force than before, for it cannot be doubted for a moment that the iron bar determines more force from pole to pole of the electro-magnet than if it were away. On the other hand, when it has attained the equatorial position, the extremities are under a much weaker magnetic force than they were subject to in the *same places* before; for the iron bar determines downwards upon itself much of that force, which, when it is not there, exists in the plane occupied by the bismuth. Hence, in passing through 90°, the diamagnetic is urged by a much greater difference of intensity of force when the iron is present than when it is away; and hence, probably, the whole additional result. The effect is like many others which I have referred to in magnecrystallic action (2487–2497.), and does not, I think, add anything to the experimental proof of diamagnetic polarity.

2693. Finally, I am obliged to say that I can find no experimental evidence to support the hypothetical view of diamagnetic polarity (2640.), either in my own experiments, or in the repetition of those of Weber, Reich, or others. I do not say that such a polarity does not exist; and I should think it possible that Weber, by far more delicate apparatus than mine, had obtained a trace of it, were it not that then also he would have certainly met with the far more powerful effects produced by copper, gold, silver, and the better conducting diamagnetics. If bismuth should be found to give any effect, it must be checked and distinguished by reference to the position of the commutator, division of the mass by pulverization, influence of time, &c. It appears to me also, that, as the magnetic polarity conferred by iron or nickel in very small quantity, and in unfavorable states, is far more readily indicated by its effect on an astatic needle, or by pointing between the poles of a strong horseshoe magnet, than by any such arrangement as mine or Weber's or Reich's, so diamagnetic polarity would be much more easily distinguished in the same way, and that no indication of that polarity has as yet reached to the force and value of those already given by Brugmann and myself.

2694. So, at present, the actions represented or typified by iron, by copper and by bismuth, remain distinct; and their relations are only in part made known to us. It cannot be doubted that a larger and simpler law of action than any we are yet acquainted with, will hereafter be discovered, which shall include all these actions at once; and the beauty of Weber's suggestion in this respect was the chief inducement to me to endeavor to establish it.

2695. Though from the considerations above expressed (2693.) I had little hopes of any useful results, yet I thought it right to submit certain magnecrystallic cores to the action of the apparatus. One core was a large group of symmetrically disposed crystals of bismuth (2457.); another a very large crystal of red ferroprussiate of potassa; a third a crystal of calcareous spar; and a fourth and fifth large crystals of protosulphate of iron. These were formed into cylinders of which the first and fourth had the magnecrystallic axes (2479.) parallel to the axis of the cylinder, and the second, third and fifth, had the equatorial direction of force (2594. 2595. 2546.) parallel to the axis of the cylinder. None of them gave any effect at the galvanometer, except the fourth and fifth, and these were alike in their results, and were dependent for them on their ordinary magnetic property.

2696. Some of the expressions I have used may seem to imply, that, when employing the copper and other cores, I imagine that currents are first induced in them by the dominant magnet, and that these induce the currents which are observed in the experimental helix. Whether the cores act directly on the experimental helix or indirectly through their influence on the dominant magnet, is a very interesting question, and I have found it difficult to select expressions, though I wished to do so, which should not in some degree prejudge that question. It seems to me probable, that the cores act indirectly on the helix, and that their immediate action is altogether directed towards the dominant magnet, which, whether they consist of magnetic or diamagnetic metals, raises them into power either permanently or transiently, and has their power for that time directed towards it. Before the core moves to approach the magnet, the magnet and experimental helix are in close relation; and the latter is situated in the intense field of magnetic force which belongs to the pole of the former. If the core be iron, as it approaches the magnet it causes a strong convergence and concentration of the lines of magnetic force upon itself; and these, as they so converge, passing through the helix and across its convolutions, are competent to produce the currents in it which are obtained (2653. 2668.). As the iron retreats these lines of force diverge, and again crossing the line of the wire in the helix in a contrary direction to their former course, produce a contrary current. It does not seem necessary, in viewing the action of the iron core, to suppose any direct action of it on the helix, or any other action than this which it exerts upon the lines of force of the magnet. In such a case its action upon the helix would be indirect.

2697. Then, by all parity of reasoning, when a copper core enters the helix its action upon it should be indirect also. For the currents which are produced in it are caused by the direct influence of the magnet, and must react equivalently upon it. This they do, and because of their direction and known action, they will cause the lines of force of the magnet to diverge. As the core diminishes in its velocity of motion, or comes to rest, the currents in it will cease, and then the lines of force will converge; and this divergence and convergence, or passage in two directions across the wire of the experimental helix, is sufficient to produce the two currents which are obtained in the advance of the core towards the dominant magnet (2671. 2673.). A corresponding effect in the contrary direction is produced by the retreat of the core.

2698. On the idea that the actions of the core were not of this kind, but more directly upon the helix, I interposed substances between the core and the helix during the times of the experiment. A thick copper cylinder 2·2 inches long, 0·7 of an inch external diameter, and 0·1 of an inch internal diameter, and consequently 0·3 of an inch thick in the sides, was placed in the experimental helix, and an iron wire core (2668.) used in the apparatus. Still, whatever the form of the experiment, the kind and amount of effect produced were the same as if the copper were away, and either glass or air in its place. When the dominant magnet was removed and the wire core made a magnet, the same results were produced.

2699. Another copper lining, being a cylinder 2·5 inches long, 1 inch in external diameter, and one-eighth of an inch in thickness, was placed in the experimental helix, and cores of silver and copper five-eighths of an inch in thickness, employed as before, with the best condition of the commutator (2675.): the effects, with and without the copper, or with and without the glass, were absolutely the same (2698.).

2700. There can be no doubt that the copper linings, when in place, were full of currents at the time of action, and that when away no such currents would exist in the air or glass replacing them. There is also full reason to admit, that the divergence and convergence of the magnetic lines of force supposed above (2697.) would satisfactorily account for such currents in them, supposing the indirect action of the cores were assumed. If that supposition be rejected, then it seems to me that the whole of the bodies present, the magnet, the helix, the core, the copper lining, or the air or glass which replaces it, must all be in a state of tension, each part acting on every other part, being in what I have occasionally elsewhere imagined as the electro-tonic state (1729.).

2701. The advance of the copper makes the lines of magnetic force diverge, or, so to say, drives them before it (2697.). No doubt there is a reaction upon the advancing copper, and the production of currents in it in such a direction as makes them competent, if continued, to continue the divergence. But it does not seem logical to say, that the currents which the lines of force cause in the copper, are the cause of the divergence of the lines of force. It seems to me, rather, that the lines of force are, so to say, diverged, or bent outward by the advancing copper (or by a connected wire moving across lines of force in any other form of the experiments), and that the reaction of the lines of force upon the forces in the particles of the copper causes them to be resolved into a current, by which the resistance is discharged and removed, and the line of force returns to its place. I attach no other meaning to the words *line of force* than that which I have given on a former occasion (2149.).

Royal Institution, Dec. 14, 1849.

ART. XIX.—*Notices regarding the plants yielding the fibre from which the Grass-cloth of China is manufactured.* Communicated by DR. D. J. MACGOWAN,* in a letter to Sir JAMES HUME, Hon. Sec. of the Agric. Society of India.

[IN consequence of communications received last year from Dr. Campbell, Superintendent of Darjeeling, and Mr. T. F. Henly, (Journal, vol. vi, part 1, p. 30,) respecting the superior character of the fibre of the *Kunchoora* of Rungpore, (*Urtica tenacissima*, Roxb.,) in which some observations were made regarding its probable identity with the plant yielding the material for the well known and valuable "grass-cloth" of China,—the Society was induced to refer the matter to Dr. Macgowan, at present stationed at Ningpo, to whose obliging kindness it is indebted for the following interesting particulars, which have been obtained partly by correspondence with scientific friends in other parts of the empire, partly by consulting botanical works and enquiring among the natives, and also from personal observations. It is worthy of remark, that the Society's museum contains several specimens of the fibre of *Urtica tenacissima*, in various stages of manufacture, received from Assam and Cachar, where it is known by the name "*Rheea*;" from the Shan country, where it is called "*Pan*;" and from Ava and the Tenasserim provinces. The plant is commonly met with in those countries; and it is also found in the Straits' Settlements, where it is called "*Ramee.*" (See Low's work on Penang and Province Wellesley.) All the correspondents of the Society, from whom specimens have been received at various intervals during the last ten years—Major Jenkins, Mr. Landers, Colonel Burney and Major Macfarquhar, speak in the same terms respecting the great strength, durability and fineness of this fibre. The Shans are stated to use it for every kind of cordage, but the Assamese and natives of Rungpore and Dinagepore, employ it merely for manufacturing into towing lines and fishing nets. The success which has attended the experiments made in Leeds and other towns in Great Britain to manufacture cloth from a mixture, in about equal proportions, of Chinese grass and sheep's wool, having led to a great demand for the former article in a raw state, it becomes a useful subject of enquiry whether the *Kunchoora* of Rungpore, and *Rheea* of Assam, could not be made a profitable article of export in competition with the China material.—*Eds. of Jour. of Agric. and Hor. Society.*]

Sir,—The inquiries you have done me the honor to propose in behalf of the Agricultural Society of Bengal, respecting the plant from which "grass-cloth" is manufactured, embrace more than can be satisfactorily answered at the present time. The subjoined account, though meagre, and in several particulars incomplete, will be found to contain much of the information you seek. It is cultivated in this vicinity, but as it is of an inferior quality, and does not flower until autumn, my description is less complete than if written in a more favored locality, or at a more advanced season of the year.

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* From the Journal of the Agricultural and Horticultural Society of India, for 1848.

Description and History.—Grass-cloth is manufactured from the fibres of a plant, called by the Chinese *Má;* it is a generic term, under which several varieties, if not species, are included, amongst these the *Tung Má*, *Pi Má*, *Sing Má*, *Tien Má*, and others are used only as therapeutic agents. Cloth is manufactured from the *Chú Má*, *Tá Má*, *Kin Má*, *Luh Má*, *&c.* There is also a species of grass-cloth made from the *Kóh:* all these have likewise a place in the pharmacopœia of China. In imitation of the native botanists from whose works this account has been mainly derived, I shall principally limit my remarks to a description of the *Chú Má*, which belongs to the natural order of *Urticeæ*—it is a *Cannabis* or hemp, but differing from *Cannabis sativa*, sufficiently to warrant another designation. Perhaps until it becomes better known, it may be called *Cannabis sinensis.* It has an irregular cellular root, of a yellowish white color, which sends up annually ten to fifteen, or more stems, to the height of from 7 to 10 feet. The stems are upright, slightly fluted, pilous, and herbaceous: its leaves are on long petioles, alternate, ovate, roundish, serrate, simple; the upper surface pilous and dark green, the lower of a silvery-grey. The flowers are described as minute, numerous, of a light green color, on a catkin-like receptacle or spike. It is found at the base of hills and on dry soils, from Cochin China to the Yellow river, and from Chusan to the farthest west that researches can for the present extend, and abounds chiefly in Kiangsú, Sy, Chuen, Kongnain, Chikiang, Fuchkien, and Canton provinces. Native writers do not include the latter province as its region. It is certainly remarkable, that there is no notice of the *Má* in the work to which you refer, [Fortune's Wanderings in China,] as it is cultivated extensively in many places visited by the author, and grows even on the walls of Ningpo. The plant is mentioned in the Chinese classics, and was undoubtedly cultivated and employed by them a thousand years prior to our era. It is mentioned in the *Shú King* as an article of tribute from the central part of China in the time of Yu, B. C. 2205: doubtless it came into use in far more remote antiquity. The Chinese *Herbal* says, "its origin is unknown."

Medical properties.—The root is described by writers on materia medica as innocuous, sweet to the taste, of a cold nature, and possessed of cathartic properties. The root, seeds, and leaves are all officinal. A long list of diseases are enumerated in which the plant is efficacious, but these throw no other light on its properties than to suggest it is comparatively inert. It is partly because of its not possessing the narcotic properties of the *Cannabis sativa*, that a difference is presumed to exist between them. In this connection I may remark, that grass-cloth is superior to linen for garments in hot climates, the latter being a rapid conductor of caloric is often unsafe, the former is not so good a conductor, and therefore more suitable. This may be owing either to the fact of the former being hot-pressed in a calender, (by which it is rendered compact and smooth, whilst the process to which the other is subjected for the same purpose, but partially affects it,) or to original differences in the fibres of European and Chinese linen.

Planting the seeds.—This takes place in May. Great care is first taken in the selection of seeds, and in the preparation of the soil. The seed should be gathered on the appearance of frost, those produced from a recent root are the best. After being dried they are stowed away in a basket or jar mixed with sand, or dry earth, others say moist earth. The jar is then covered with straw to protect the seeds from the cold, as if exposed to its influence they yield an imperfect plant. Before planting, the seeds are tested by immersion in water, those which float are to be rejected, those at the bottom planted. A loose dry soil is to be selected, if near a canal or rivulet it is preferable. The ground is to be well ploughed, and broken finely, manured, and then divided into beds about eight yards long, and one wide; the beds are to be raked, and afterwards made compact with a hoe. After this it is watered and left for a night: on the following day raking up and pressing down is repeated. The beds being smooth, two or three table spoonsful of seed are mixed with a bowl of earth, and sown broad-cast over half a dozen beds, then they are swept with a broom to cover the seeds. In some places the seeds are first made to sprout, and then planted in drills, which are carefully filled up. Just before the blades appear, a framework is to be constructed over the beds, on which mats should be spread to protect them from the heat of June and July. The matting must be kept moist by day and removed at night, that the blades may receive the dew of heaven. The beds are to be constantly weeded. When the plant is about two inches high, the framework and matting may be removed. When three inches high, it should be transplanted, having been well watered the night before; the blades should be taken up separately with a portion of earth and planted in a field far removed from mulberry trees, about four inches apart. It may form a border to the ceralia and vegetables, protecting them from the depredations of domestic animals, all of which avoid the *Má*. In dry weather, the field is to be watered every three or four days, until the second decade, when it may be watered every tenth day. In November and December manure it with horse or buffaloe dung, earth, straw or any rubbish, a foot or more thick, to protect it from cold. In March rake it away and expose the plant, watering it in dry weather, and using rubbish of any kind for manure. A caution is given never to use swines' dung, as it is "saltish" and hurtful to the *Má.* In the third or fourth year, some say in the second, the plant may be cut and used.

Planting the roots.—The roots are to be cut into pieces of three or four fingers' length, and are to be planted in May, half a yard apart, and watered every three or four days. On the appearance of the blades use the hoe and water them; they will be mature for cutting in the second year. In the course of ten years the roots become unfruitful, the shoots may then be cut off, and if enveloped in earth, and covered with matting, can be transplanted in places 30 or 40 inches distant. The ground should be first well prepared with manure, and freely manured afterwards: the manure being half water. Here, as before, the plants should be hoed from time to time. In many cases fresh earth, pulverized bricks, ashes, &c., are used for manure. Some years the husbandman has his crop injured by worms, he needs therefore to seek for and destroy them as they appear by picking them off. It not unfrequently happens, that the crop is in some places remarkably small, and sometimes the produce is very great without assignable cause.

Cutting the Má.—It yields three crops every year. The first cutting takes place in June. Care is to be taken not to cut the young shoots, keep therefore an inch from the ground. In a month or two, the shoots are seven or eight feet high, when the second cutting takes place: do not cut the original stem. During the latter part of September, or in October, the last cutting is performed, from which the finest cloth is made: the first being inferior, coarse, and hard. After each cutting, the plant is to be covered with manure, and watered; but not day by day unless it be cloudy. At Canton the plant is pulled up by the roots every year, from which it is evident that it differs widely from the *Má* just described. Perhaps that which is produced at Canton is *Cannabis sativa.*

Peeling the Má.—On being cut, the leaves are carefully taken off with a bamboo knife, by women and children, generally on the spot. It is then taken to the house, and soaked in water for an hour, unless it is already wet by recent showers. In cold weather the water should be tepid. After this the plant is broken in the middle, by which the fibrous portion is loosened, and raised from the stalk; into the interstice thus made, the operator, generally a woman or a child, thrusts the finger nails, and separates the fibre from the centre to one extremity, and then to the other.

The striping process is very easy. It appears to be difficult to remove the fibres from the Canton *Má*, as it is soaked in water for more than 48 hours before peeling, which is done by men. They first cut off the roots, and then separating the fibre from the stalk, strip it off by drawing it over a pin, fixed in a plank. In either process half of the fibre is taken off at one stroke. The next process is scraping the hemp, to facilitate which the fibre is first soaked in water. The knife or scraper is about two inches long; its back inserted in a handle of twice the length. This rude implement is held in the left hand, its edge which is dull, is raised a line above the index finger. Strips of hemp are then drawn over the blade from within outwards, and being pressed upon by the thumb, the pilous portions of one surface, and the mucilaginous part of the other are thus taken off. The hemp then "rolls up like boiled tendon:" after being wiped dry, it is exposed to the sun for a day, and then assorted, the whitest being selected for fine cloth.

Bleaching and dividing.—A partial bleaching is effected on the fibres, before they undergo further division, sometimes by boiling, and at others by pounding on a plank with a mallet. These operations are in some places repeated. After being dried in the sun, an important operation then succeeds by women and children, to whom is entrusted the tedious process of splitting the fibres, which they do with their finger nails. Expert hands are able to carry this division very far. When this process has been preceded by hatcheling, the shreds are finer and softer. The threads are formed into balls, and subjected to frequent soaking and washings. The ashes of the mulberry leaf are recommended to be put in the water with the hemp, others use lime, for a whole night. Some simply expose it to dew and sun. In rainy and cloudy weather, it should be exposed to a current of air in the house: moisture darkens it. The threads are now ready for splicing, the work of women and children, the labors of the agriculturist being concluded when the threads are rolled into balls, after being sized or stiffened with rice-water. Before the thread is ready for the weaver, the balls are steamed over the vapor of boiling water in a closed oven. They are then spread out to dry. The subsequent stages, until the cloth is removed from the loom, include nothing which interests, or at least instructs, artizans in the West.

Varieties of the Má.—The *Chú Má* is found wild, but in this state attains only three or four feet, and is seldom used except for twine. *King Má* grows nearly as high as the *Chú Má*, the fibre is separated only by rotting in water. The stalks are dipped in sulphur and employed for matches. Its flowers are yellow. Very coarse cloth and sandals are made from its fibre. The thread of this *Má* made in *Kongsi*, is said to be as fine as silk. *Tá Má* or *Hán* (dynasty) *Má*, and also called fine hemp, is likewise employed for making cloth and for ropes; its fibre is used as a support to the pith employed as candle wicks. *Luh Má* produces the hemp of which rice bags are manufactured, and also ropes. The *Tung Má* and the *Pi Má* are used for making pigments, one serving for cakes, the other for paper. The only other *Má* that need be named in this list is the *Chí Má*, *Sesamum indicum.* It was brought from India in the reign of Kingti, B. C. 156. It is now found in all parts of the empire. Its seeds are used in cakes, and like almost every kind of *Má*, it yields oil. *Flax.*—It would seem from various English and Chinese Dictionaries, that flax is found in China, but of the existence of *Linum usitatissimum*, I cannot discover the slightest evidence. It seems to have been confounded with the last named plant. The above are all the facts respecting the *Má* which I have been able to glean from native authors; the deficiency can only be supplied by personal observation. The *Chú Má* of this place can be inspected and described when in flower. This imperfect account of the plants producing the fibre from which the grass-cloth of commerce is manufactured (evidently a misnomer), would be yet more defective were the *Kóh* plant to be wholly omitted. It is described as a creeper, which every year springs from an immense root, and grows from ten to thirty feet in length, clinging to trees when within reach. The root is purple on the outside, and white within; it is made into flour like arrow-root. I have found it an useful substitute for the *Maranta arundinacea.* Its leaves have three points, they are long, green on the face, and bright below. In August it has blended purple flowers. The fibre is strongly adherent to the stalk, and is only loosened by boiling it in water. It is then taken off with the finger nails, exposed for a long time to running water, and beaten with mallets. It undergoes the same processes as the *Má*, but seems to require more beating and boiling: wooden utensils make it dark. The *Kóh*, like the *Má*, has been manufactured from high antiquity, and is found throughout the same extensive region in which the latter abounds. The cloth made from it is *yellow*, and as fine as ordinary grass-cloth; it cannot be bleached white; in summer it is much worn by respectable Chinese. The best brought to Ningpo, is called *Háinán Kóh* cloth, and is perhaps manufactured on the island of Háinán. If by the *Kunkhura* you mean the *Urtica tenacissima* of Roxburgh, it is probable that it is a different plant from either variety of the *Má.* As the hindrance to the manufacture of the former is owing to the difficulty attending the peeling of the fibre, would it not be well to treat it, as the Chinese do the *Kóh*, viz. by boiling? If the *Kunkhura* should prove useless, may not the catalogue of Dr. Wallich, which contains forty-seven species of *Urticeæ*, include the *Má*, the *Kóh*, or an available substitute? The observations of Dr. Roxburgh, on the various specimens of fibrous vegetables, the produce of India, may perhaps be consulted with advantage in connection with the Chinese account of the *Má.* Besides the enclosed, I shall only be able to send you some seeds of the *Chú Má.* There can be no doubt that if the seeds of the proper kind be procured from China, the plant may be introduced into India if it be not indigenous to her soil. To secure success it would perhaps be well to procure them from each of the open ports of China. From Canton is exported the finest cloth manufactured in the empire. This superiority the Chinese attribute to the greater skill of the Canton workmen. Foreigners have referred that fibre to two plants, *Cannabis sativa*, and *Sida tilæfolia* (Dr. Abel).* From Shanghai is exported the fine strong fibre you have referred to, the *Urtica nivea.* It was through the efforts of the H. E. I. Company of Canton, that seeds were procured and forwarded to England. By referring to the 47th page of the 72nd Vol. of the Philosophical Transactions, there will be found a paper on Chinese Hemp by Mr. Furgusson, and a notice of the experiments tried with the seeds in England, (vid. Encyc. Britannica.) Had they possessed the hints here extracted from Chinese writers on this plant, the experiments of the gentlemen named in the above paper would probably have been more successful. Should the Society wish to pursue the subject further, some useful information may be obtained from a series of sketches, 120 in number, illustrating the culture and manufacture of grass-cloth, by Tinqua, 12 New China st., Canton, a translation of the text accompanying the drawings may be found in the Chinese Repository for May, 1847. It was the special province of Monsieur Hedde, of the late embassy from France to China, to collect facts and specimens illustrative of the agriculture and manufactures of China. The result of his observations have, I believe, been published in Paris, containing a notice of one variety of the *Má.* Osbeck, a pupil and countryman of Linnæus, and Dr. Abel, Naturalist of Lord Amherst's embassy, have noticed the *Má.* The Agricultural Society of Bengal, aiming to develope the industrial resources of a great empire, and thereby to improve its inhabitants, has a claim upon the services of all who can contribute in any manner to its objects. Allow me to assure the Society, that I shall take great pleasure in responding to any further calls you may have occasion to make.

Ningpo, June 1st, 1848.

Note by Dr. Falconer.—As there are no specimens accompanying Dr. Macgowan's paper on the grass-cloth of China, it is impossible to decide as to the accuracy of his statement that the fibre is produced by a species of *Cannabis*, which he provisionally calls *Cannabis sinensis*. This point cannot be determined without an examination of the flowers;* and Dr. Macgowan does not appear to have seen them. But the description given by him is entirely that of the species of *Bœhmeria* (formerly *Urtica*), called *B. nivea* or *tenacissima* by botanists, or of a nearly allied species; and I am not aware of any evidence to support the idea that the China grass-cloth (*Chú Má*) is derived from a species of *Cannabis*. One of the other kinds mentioned by Dr. Macgowan, *King Má*, was forwarded to Mr. Roxburgh, from Canton, by Mr. Kerr, in 1812.

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* It has also been referred to *Corchorus capsularis.* Vide Bennett's Wanderings in N. S. Wales and China.—*Eds. of Jour. of Agric. and Hort. Society.*

ART. XX.—*On the Quantity of Heat evolved from Atmospheric Air by Mechanical Compression;* by JOHN GORRIE, M.D.

(Concluded from p. 49.)

THE arrangement of the following tables is deemed sufficiently clear to render their object intelligible; the first column represents the date of the experiments, and the second the hours at which observations were made and the duration of the experiment. The next three columns represent a series of observed temperatures: the first gives the temperature of the atmosphere; the second shows the temperature of the water used for absorbing the heat of the condensed air, before injection; the third shows the temperature of the same water after the process of injection has enabled it to absorb all the heat it can take up from the condensed air; it also represents the sensible temperature of the air after admixture with the water of injection. Following these, are two columns; the first showing the apparent tension of the air in the reservoir, in atmospheres, as indicated by the gauge; the second the number of revolutions of the engine per minute. The three next columns represent certain quantities of air: the first gives the quantity in cubic inches condensed at each stroke of the pump; the second the quantity in cubic feet condensed per minute; the third, the quantity in pounds avoirdupois, condensed per minute. In calculating this last column I have taken 525 grains as the weight of a cubic foot of air, at a temperature of 60° F. and mean barometric pressure; and applied Dalton and Gay Lussac's law, that it dilates and contracts $\frac{1}{480}$ of its volume for every increase and diminution of its temperature of 1° F. from the fixed point of 32° F. Of the two remaining columns the first shows the quantity of water in pounds, injected into the condensing pumps, at each stroke of the piston; and the last the quantity of the same water injected per minute.

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* A second reference has been made to Dr. Macgowan on this point, and specimens will no doubt be shortly received.—*Eds. of Jour. of Agric. and Hor. Society.*
Dr. Macgowan writes that he has forwarded seeds to the Patent Office, Washington, and to the American Institute.

TABLE I.

Experiment made at Cincinnati.

Date.	Hour.	Temperature of the			Apparent tension of air in atmospheres.	Revolutions of engine.	Quantities of the				
		Atmosphere.	Water before injection.	Water after injection.			Air condensed at each stroke of the pump.	Air condensed pr. minute in cubic feet.	Air condensed per minute in pounds.	Water injected per stroke in pounds.	Water injected per minute in pounds.
1848.	A. M.										
Nov. 21,	11.	42	45								
	11.30	"	"	51	5½	13	3144	47·305	3·627	2	52
	12.	44	"	53 –	6	15	"	54·583	4·210	"	60
	P. M.										
	12.30	"	"	53	6½	"	"	"	4·210	"	60
	1.	46	45+	54	6½	"	"	"	"	"	"
	1.30	45	45	53	6	15½	"	56·400	4·350	"	62
	2.	44	"	56	"	15	"	54·583	4·210	"	60
	2.30	"	"	53–	"	"	"	"	"	"	"
	3.	"	"	"	5½	"	"	"	"	"	"
	3.30	"	"	"	5½	"	"	"	"	"	"
	4.	"	"	" –	6	"	"	"	"	"	"
	4.30	43	"	"	5¾	"	"	"	"	"	"
	5.	43	"	"	6	"	"	"	"	"	"
Average and difference,				8–	6+	15	3144	54·583	4·210	2	60

Remarks.—In this experiment only the larger condensing pump was used.

The pump being near the steam engine furnace, the air entering it was considered 4° above the open air, (or at 60 F.)

The difference at 2 P. M., of 11° between the water before and after injection, was supposed to be owing to the imperfect working of the jet pump.

In the course of the experiment there were several stops of about 15 minutes each.

From the data presented by the table, it would seem to be an easy matter to form a quantitative determination of the heat evolved by the condensation of atmospheric air. The difference of temperature in the water of injection, before and after injection, the quantity of air condensed, and the quantity of water heated per minute, are all the elements necessary for the calculation at any given tension. By reference to columns 4 and 5, this difference of temperature, in the preceding experiment, is found to be 8° F., the quantity of air condensed per minute, is, according to column 10, 4·210 pounds, and column 12 shows that an average of 60 pounds of injection water is heated per minute. A simple multiplication of the first and last numbers, would, if they were correct, show the actual quantity of heat evolved per minute, by the beforementioned quantity of air subjected to a condensation of six atmospheres: Thus, 8° × 60 = 480°, is the number of degrees one pound of water is heated in a minute. If we divide this amount by 140° F., for the latent heat of water, and the standard measure of heat I have adopted, it will give (480 ÷ 140 =) 3·429, for the number of pounds of ice that the heat would melt per minute. This product being again multiplied by 360′, for the duration of the experiment in minutes, gives (3·429 × 360 =) 1234, or, multiplied by 1440, for the number of minutes in a day, gives (3·429 × 1440 =) 4938, for the number of pounds of ice which the heat evolved in the preceding experiment, would melt in a day.

But there are several circumstances which interfere with this simple calculation, and which require to be considered, and their distinct effects computed before we can arrive at a just conclusion as to the value of the experiment.

1. From the construction of the perforated plates, or "roses," through which the water of injection was delivered to the air in the act of condensation, as well as from the arrangement of the pipes which transmitted the mixture of air and water to the reservoir, I can have no doubt that the latter performed its duty of absorbing as much of the heat set free by the condensation, as possible; but still it could only be a mixture, and the air had, at least, the same temperature as the water. The air was thus possessed of 8° F. more of sensible temperature than when it entered the pump. This additional heat forms an uncompensated equation of temperature of appreciable magnitude requiring an indispensable allowance for its effects. That these were very considerable was rendered evident in the subsequent expansion of the air; for, while besides a diminution of the calculated cooling effects, various parts of the engine, in which the expansion took place, equally exposed to the atmosphere and less favorably influenced for the convection of *cold*, were covered with ice, produced from the condensation of atmospheric vapor, the air-pipe, communicating between the reservoir and the engine, was free from frost or moisture during the continuation of the experiment, though, upon its ceasing, it became speedily covered with frost. In forming an estimate of the proportion which the operation of this free heat bears to the whole of the heat evolved, it seems to be necessary to take into consideration the different specific heats of air under the ordinary atmospheric pressure and the various states of condensation at which experiments may be made.

This is a difficult subject of investigation, and one on which my labors have not led me to satisfactory results, or to an arrangement of them sufficiently clear and accurate to justify my presenting them to the public. But as it is not my present object to solve all the delicate questions which this subject presents, but simply to attain such approximations to facts, as may enable practical men to render them subservient to their purposes, I shall not enter into the minute examination of this subject. A few experiments are recorded in scientific works which show that the specific heat of air, at different densities, diminishes at a much slower rate than its specific gravity: thus, according to the observations of Clement and Desormes, the specific heat for air for equal volumes, at temperatures from 32° to 140°, and barometric pressure from 3·74 to 39·6, increased in a ratio as follows, viz.

Barometric pressure.		Specific heat.
at	39·6	1·215
"	29·84	1·000
"	14·92	·693
"	7·44	·540
"	3·74	·368

From this table it is apparent that the specific heat of atmospheric air, considered in the ratio of its weight or mass, diminishes as the density increases; and it may be calculated, that when air in the same volume is condensed to double its density, its specific heat is increased from 1·000 to 1·467; when its density is quadrupled it becomes 1·883; and when its density is eight times increased its specific heat is 2·717. The densities increasing in the geometrical progression 1, 2, 4, 8, correspond nearly to the specific heats in the arithmetical series, 5, 4, 3, 2.

If the view I have taken of this law be correct, and it be applicable to an explanation of the heating operation of air in the condition referred to, we are prepared to examine the extent of its influence. Before, however, this can be determined, we must form an estimate of the whole amount of heat evolved by and at the specific heat of air, under a given degree of condensation, in order to assign the proportion that belongs to that in the reservoir. By referring to the 10th column of the preceding table, we find that an average of 4·210 pounds of air condensed with a force of six atmospheres, heats 60 pounds of water 8° F., or, that one pound of air heats 14·250 pounds of water 8° F., or, that one pound of air heats one pound of water 114° F. As the specific heat of air at ordinary temperature and pressure is 2669, one pound of it, in evolving heat enough to warm an equal quantity of water, 114° F., must set free what would heat itself, 427° F., besides the 8° F., which, in the experiment, it retained above the atmospheric temperature. Under a condensation of six atmospheres the specific heat of air, we have seen, is about 2·500; and this amount must be multiplied by 8° F., for the extra temperature of the air in the reservoir, making 20° F. to enable it to represent its proportional heating effect. Now, the proportion of 20° F. (the equivalent to the free heat in the reservoir) to 427, (the remainder of the heat evolved by condensation) is, nearly, as 1 to 21; and, therefore, the relation of the heat retained by the air, after admixture with the water of injection, is equal to about one twenty-first part of the 8° F., which the water of injection absorbs, or is about the $\frac{38}{100}$ of a degree of Fahrenheit at the specific heat of water.

2. Another correction of the table is necessary on account of the heat of condensation, which the water of injection is unable to absorb, imparting an increased elasticity to the air in the reservoir. This air being confined within fixed bounds, the effect of the heat is to increase its pressure on the surface by which it is confined, instead of the natural one of enlarging its dimensions. The consequence is that the gauge of the reservoir marks a higher tension than it would have if all the free heat of the air were absorbed. The actual changes of elasticity which are produced by mechanical condensation, without allowing the compressed air to lose any heat after compression, and for all proportions in which that heat is retained, have been mathematically investigated. They are expressed, however, by theorems too abstruse, in comparison with the importance of the object to be at present attained, to find a place in this communication. Possessing a more important bearing upon the quantity of cooling effect produced by the expansion of condensed air, and still more in a relation with the quantity of mechanical power consumed in the condensation of air, they will be examined more minutely when I come to consider these portions of my subject. At present I deem it sufficient to say that, from the partial calculation I have made, I feel authorized to consider that 8° F. of unabsorbed heat add to the elasticity of air, under a tension of six atmospheres, about one-third of an atmosphere of pressure.

3. Radiation is a cause of diminution of the apparent heating effect from the condensation of air, requiring a correction for perfect accuracy. The loss of heat from this cause is dependent somewhat upon the nature of the material and extent of surface, but more upon the difference between the temperature of the hot body, and that of the surrounding medium. As this difference, in the case before us, is but 8° F., the rate at which heat is lost must be very small, and scarcely appreciable by instruments.

4. A correction of an opposite character must be made for the heat generated by the friction of the piston and piston rod of the pump. Attempts were made, in the course of this and other experiments, to ascertain the precise quantity of heat generated by this means, but they were not successful. Upon propping open the induction valves of the pump, so as to allow free ingress and egress to the air, while the piston worked and the water of injection flowed as usual, I could not perceive by the thermometer, any change in the temperature of the water. Yet all experience

proves that heat is generated by friction; and Rumford has shown that the quantity is very considerable. According to an experiment directed towards attaining the maximum heating effect from this cause, he found that a mechanical force of one horse power evolved heat enough to raise the temperature of 26½ pounds of water 90° F. in 2½ hours; which, it may be easily calculated, is sufficient to melt 6⅔ pounds of ice per hour. I consider that upon the principle on which the friction of the steam engine and similar machines is usually calculated, the condensing pump, used in this experiment, consumed nearly one-half of a horse power. If this assumption be correct, and Rumford's experiment be considered a standard formula for such calculations, the heat generated by the piston and piston rod must have been equivalent to the fusion of about eighty pounds of ice per day; or was equal to an increase of temperature of (80÷5000=8°÷625) ·125 of a degree.

Applied to the data of the preceding table, these corrections will make the whole amount of heat evolved by air, compressed with a force of six atmospheres, as follows:

Heat as shown by the water of injection, ...	8°
" added, for correction 1, ...	·375
" " " " 2 " " " " 3 } estimated at . .	·125
	8°·500
" deducted, for correction 4, ...	·125
	8°·375

Now, as 60 pounds of water were heated 8°.375 per minute, heat enough must have been disengaged, by the machine, to melt (60×8°·375÷240=)3·575 pounds of ice per minute or (3·575×144=) 5660 pounds per day.

Having explained in a general way the principles concerned in correcting the data, furnished by experiment on our mode of determining the heat evolved by the condensation of air, we are prepared both to exhibit and correct any number of experiments. The principles are seen to be general conclusions, affording approximations only to the position in which truth lies, and requiring modifications before they can be considered representations of actual facts. They are therefore of value, chiefly, as guides in future experiments, by which they may be confirmed, or, if erroneous, rendered accurate. Such as they are, I have applied them to the correction of the following tables.

TABLE II.

Experiments made in New Orleans.

Date.	Hour.	Temperatures of the			Apparent tension of air in atmospheres.	Revolutions of engine.	Quantities of the				
		Atmosphere.	Water before injection.	Water after injection.			Air condensed at each stroke of the pump.	Air condensed per minute in cubic feet.	Air condensed per minute in pounds.	Water injected per stroke in pounds.	Water injected per minute in pounds.
1849.	A. M.										
June 23	10	82	79	84	2	22	3144 206	85·300	6·093	2	88
	P. M.										
" 29	1.	82	79	82	"	18		69·791	4·985	2	72
" "	1.30	"	79	84	"	"	"	"	"	"	"
" "	2.	83	79	84	"	"	"	"	"	"	"
	A. M.										
July 25	7.30	79	76	80	"	17	"	65·914	4·708	2	68
" "	8.	82	79	84	"	"	"	"	"	"	"
" "	9.	"	79	84	"	"	"	"	"	"	"
" 26	8.	84	77	82	"	"	"	"	"	"	"
Average and difference, 5° –					2	18	3350	69·791	4·985	2	72

Remarks.—In these experiments both pumps were used. The observation on the experiment of June 23, was made while the reservoir was being rapidly charged to 8 atmospheres. In the other experiments the tension in the reservoir was steadily maintained at 2 atmospheres.

This table is drawn up from experiments made on four different days, and under some variations of circumstances, in regard to the temperatures of the atmosphere and water of injection, as well as the manner in which they were performed. The resulting difference between the temperatures of the water before and after injection, after the pump and its appendages were raised to a temperature common with the latter, was so nearly uniform, for all the experiments, that it may be considered identical. It shows, according to the thermometers used, that two pounds of water were heated 5° F. at every stroke of the pump; or, that 3350 cubic inches of air, compressed till its density was doubled, heated two pounds of water 5° F. This is a little above the average, and it may be more correct to consider the amount of heat 4°·75.

To this must be added for correction, 1, on account of heat retained by condensed air, ...	2·50
" " " " 2, " " of over-estimate of pressure of air, " " " " 3, " of radiation,	·175
	5·175
From this must be deducted for correction 4, on account of heat from friction, ...	42
	5·133

The causes interfering with the accuracy of operations of the present character are so delicate and intricate in their nature that it cannot be expected a few experiments should be deemed sufficient to settle them with mathematical precision; yet, we cannot err on the side of too great a quantity in assuming that fully $5\frac{1}{8}°$ is the action of the aforementioned quantity of air, condensed to double its density, from its atmospheric condition, upon the specified quantity of water.

TABLE III.

Experiments made in New Orleans.

Date.	Hour.	Temperatures of the			Apparent tension of air in atmospheres.	Revolutions of engine.	Quantities of				
		Atmosphere.	Water before injection.	Water after injection.			Air condensed at each stroke of the pumps.	Air condensed per minute in cubic feet.	Air condensed per minute in pounds.	Water injected per stroke in pounds.	Water injected per minute in pounds.
1849. June 23	A. M. 10.10	82	79	85	4	18	3144 206 3350	69·791	4·985	2	72
" 25	P. M. 12.30	84	78	84	"	15	"	58·015	4·144	"	60
" 29	4.	80	80–	86	"	17	"	65·914	4·708	"	68
" "	4.15	79	79	86	"	"	"	"	"	"	"
July 25	A. M. 11.30	84	79	85+	"	15	"	58·015	4·144	"	60
" "	12.	"	79	86	"	18	"	69·791	4·985	"	72
" "	P. M. 12.45	"	79	86	"	16	"	62·037	4·431	"	64
" 26	A. M. 8.	82	77	84	"	15	"	58·015	4·144	"	60
" 27	8.	"	77	83	"	17	"	65·914	4·708	"	68
" "	9.30	86	78	84+	"	16	"	62·037	4·431	"	64
" "	10.30	84	78	84+	"	15	"	58·015	4·144	"	60
" "	M. 12.	86	78	85	"	16	"	62·037	4·431	"	64
Average and difference,				7°	4	16	3350	62·037	4·431	2	64

Remarks.—The tension in the reservoir, as marked by the gauge, was seldom at exactly 4 atmospheres; it was sometimes a little above and sometimes a little below the mark.

The difference of temperature between the water before and after injection I consider as full 7° F.

From this table it may be deduced that the condensation of 3350 cubic inches of air, at the ordinary pressure, and a mean temperature of 84°, to one-fourth of its volume, disengages heat enough to raise the temperature of two pounds of water 7° F. Applying the principles of correction heretofore established, we must add for correction on account of heat retained by the condensed air, ·333

7·333

Add for correction number 2 } estimated at, . . ·110
" " " " 3 }

7 ·443

Deduct for " " 4 heat from friction, . 83

7°·360

TABLE IV.

Experiments made in New Orleans.

Date.	Hour.	Temperatures of the			Apparent tension of air in atmospheres.	Revolutions of engine.	Quantities of				
		Atmosphere.	Water before injection.	Water after injection.			Air condensed at each stroke of the pumps.	Air condensed per minute in cubic feet.	Air condensed per minute in pounds.	Water injected per stroke in pounds.	Water injected per minute in pounds.
1849. June 18	P. M. 1.15	80	79	87	8	20	3144 206 3350	77·542	5·538	2	80
" "	2.	"	79	88	"	"	"	"	"	"	"
July 26	1.	74	77	86	"	15	"	58·015	4·154	"	60
" "	1.30	78	77	88	"	"	"	"	"	"	"
" "	2.30	82	77	86	"	16	"	62·037	4·431	"	64
" "	4.30	"	"	85	"	15	"	58·015	4·144	"	60
" "	5.30	"	"	85	"	"	"	"	"	"	"
" 27	12.30	"	78	86+	"	16	"	62.037	4·431	"	64
" "	1.30	84	81	89	"	15	"	58·015	4·144	"	60
" 28	1.40	82	78	86+	"	"	"	"	"	"	"
" "	3.15	"	"	86	"	16⅓	"	63·975	4·569	"	66
" "	5.30	86	79	87+	"	16	"	62·037	4·431	"	64
" "	7.45	82	78	86+	"	"	"	"	"	"	"
Difference and average,				8¼° F.	8	16	"	62·037	4·431	2	64

Remarks.—On July 26, at 1°.30′ it will be observed the difference of temperature of the water of injection, before and after injection, was 11° F. This unusual quantity of heat, as in the first experiment, was supposed to be owing to imperfect working of the jet pump, thereby causing a less than the regular qnantity of water to be injected.

As in the former tables, the data for table IV. are taken from experiments made on different days. It appears from a comparison of the fourth and fifth columns, that the difference in temperature of the water, before and after injection, several times indicates 9° F., but as it was oftener simply a full 8° F., I have not thought advisable to take 8°·5 for the mean of observation, though I feel assured there can be no exaggeration in considering it . . . . 8°·250

Add for correction number 1	·400
" " " " 2 " " " " 3 }	·135
	8 ·785
Deduct for " " 4	·125
	8 ·660

In the deductions I have made from the preceding tables, I have supposed that the allowances for the real over the apparent pressure of the air in the reservoir, and for radiation, are about equal to the opposing effect from friction. According to the mode of proceeding we shall have 8°·660 as the quantity of heat evolved from 3350 cubic inches of air as subjected to a compressing power of eight atmospheres at a temperature of about 84° F.

I have deemed it necessary, for a full elucidation of the subject before us, to append a table of deductions, drawn up from some of the data furnished by the preceding tables. In explanation of this table it may be stated that the first column is intended to represent the mean temperature of the atmosphere during the time of the experiment. Column 2 gives the mean difference between the water of injection before and after injection; and the 3d is designed to show the difference, in the same water, under the various corrections which must be made upon the simple thermometrical observations. The 4th column represents the tension of the air in the reservoir, according to observation; and the 5th the same tension as corrected for excess of temperature.

To enable us to compute the effects without great and undue labor, it is necessary to reduce both the air and the water, used in the experiments, to some common measure or weight. The pound weight as the most convenient standard, has been adopted. By reducing columns ten and twelve, of the preceding tables, to the common rate, we have obtained column 6 of the following table.

The 7th column shows the quantity of heat set free by the condensation of one pound of air at the specific heat of air. The figures in the column are ascertained by assuming that the specific heat of air—assigned by Delaroche and Berard, viz., ·2669 water being 1·0000—is correct, and then multiplying the quantity by the number of degrees, F., one pound of air heats one pound of water, under a given degree of compression, as shown in column six. It is in truth a mere representation of the intensity of heat evolved by the simple condensation of air.

Columns 8 and 9 show the quantity of heat—expressed in the number of pounds of ice it would melt—which the engine is capable of producing in twenty-four hours, at fifteen and twenty revolutions per minute; and are introduced as suggestive of pecuniary considerations.

The 10th and 11th columns show the difference in the degrees of heat, at the specific heats of water and air, which the air in certain states of condensation disengages.

As my object, in conducting the foregoing experiments, has been to furnish practical rather than scientific data, I have not thought it appropriate to introduce the calculations of the following table in full, nor have I attempted their perfect accuracy. The results set down for the tension of 3, 5 and 7 atmospheres must be considered as rather the deductions of careful conjecture than the precise answers to either observation or calculation. It is no doubt practicable to make observations which shall express a very close approximation to the actual temperature evolved from air, for all tensions; but it would require thermometers of much greater delicacy and accuracy than I could obtain, and some modifications of the mode of experimenting pursued. It is, therefore, desirable on both scientific and practical grounds, that a more extended series of experiments on air, similar to those above detailed, should be made, with such improved and superior apparatus, as experience has demonstrated is necessary, and with the care and skill which none but those practised in such matters are competent to exercise. In the mean time, the following table may be regarded as sufficiently near to truth to present a plain view of the objects for which it was drawn up; and any one who is so disposed may test its general correctness by particular examples.

TABLE V.

Deductions from Tables 1, 2, 3, 4.

Mean Temperature of			Apparent tension of air in atmospheres.	Real tension of air in atmospheres.	Quantity of heat set free by the condensation of				Ratio of difference of heat set free at specific heat of water.	Ratio of difference of heat set free at specific heat of air.	Remarks.
The atmosphere.	The difference between the water before and after injection.	Corrected difference between the water before and after injection.			One pound of air at specific heat of water.	One pound of air at specific heat of air.	Air expressed in pounds of ice per day, at 15 revolutions of engine.	Air expressed in pounds of ice per day, at 20 revolutions of engine.			
83	5°.–	5.125	2		74.	277	3112	4220	74.	277	By observation.
"	6 .5		3								" calculation.
84	7.–	7.333	4		105.	395	4474	5966	31.	118	" observation.
"	7 .5+		5								" calculation.
46	8.–	8.333	6	5.666			5150	6866			" observation.
83	8.+	8.500	7								" calculation.
"	8°.25	8.666	8	7.500	125.	472	5343	7125	20.	80	" observation.

Before adverting to the particular object for which the foregoing table was drawn up, I may mention that the question of the quantity of heat evolved by air, under a tension of eight atmospheres, was subjected to another and very simple test, which confirmed the accuracy of the deductions comprised in the last line. During an experiment of an hour's duration, the water of injection, instead of being supplied as usual by the city hydrant, was taken from and returned to a butt of about 130 gallons capacity, containing about 1100 pounds of water. At the commencement of the experiment, the temperature of the water was 77° F. (the atmosphere being 79° F.), at the end it was 112° F., the engine working twenty revolutions a minute. The quantity of ice, which the heat thus disengaged would melt, is equal to (1100 × 35 ÷ 140 =) 275 pounds, or for twenty-four hours 6600 pounds. There was but a very slight diminution in the rate at which the temperature of the water increased.

In corroboration of the general accuracy of the experiments it may be further mentioned, that the converse of the result here sought, viz., the quantity of heat which the condensed air in its expansion is capable of absorbing, or, in other words, the quantity of ice it is capable of producing, was, after making due allowances, sufficiently nearly equal to the quantities as set down in columns eight and nine, to prove that there has been no material error of observation or calculation.

The chief object of Table V. is to present in a form obvious at a glance, the changes of temperature which correspond to proportional changes in the density of air. Philosophers have so often found the phenomena of nature conforming, in all their circumstances, to uniform laws, that they seem to have supposed the evolution of heat, from the mechanical condensation of air, must follow some course of regular progression. The convenience to experimenters which has resulted from the establishment of that law by which aerial bodies adjust their volume and pressure exactly to each other, has induced them to hope that one equally simple would be discovered for measuring the proportion of heat set free from air by condensation. And, under the impression that such a law must exist, equal proportions of heat have been considered to be set free, under regular diminutions of volume, or increase in density of air. Thus, Dalton, finding, on experimenting with a small quantity of air, that when it was doubled in density it evolved 50° F. assumed this as the measure for every subsequent doubling of its density. Leslie, observing a similar result, from restoring dilated air to its natural density, assigned a similar quantity of heat to a similar reduction of volume; but as a law founded on such a result was incompatible with the phenomena presented by a greater increase of density, he deduced the following rule for determining the change of temperature produced by any degree of rarefaction or condensation of air, viz.: "Multiply 25 by the difference between the density of air and its reciprocal, the product will be the difference of temperature on the Centigrade scale." Thus, if the density be doubled or the rarefaction reduced to one half, $25 \times (2 - \frac{1}{2}) = 37\frac{1}{2}^\circ$ Centigrade ($= 67\frac{1}{2}$ F.) indicates the change of temperature by doubling the density or rarity of air. By this formula the quantity of heat evolved by the higher degrees of condensation is enormously increased; for if the air were condensed 30 times we should have $25 \times (30 - \frac{1}{30}) = 749^\circ$ Centigrade (1412° F.) for the elevation of temperature. It may be remarked of this reasoning that it represents an hypothesis more nearly the reverse than in conformity with any natural law, of an increase or reduction of temperature, deducible from experiment. Mr. Ivory, acting upon a similar view of natural progression, expresses a rule for the changes of temperature, corresponding to given changes of density, by assigning 1° F. as the quantity of heat evolved from air, under a reduction of $\frac{1}{186}$ of a volume, no matter of what density. The preceding tables of experiments, however inexact they may be, are sufficiently extended and precise to prove that all the above formulæ are erroneous.

But so probable, at the outset of my experiments, did it appear that the relation between the condensation of air and the disengagement of heat, followed some law of arithmetical or geometrical proportion, and so firmly was the probability impressed on my mind, that observations of a different tendency produced only doubts of their accuracy. The quantity of heat obtained by reducing air from its atmospheric state to half its volume, I assumed as the basis of a calculation for every subsequent similar reduction, until frequent repetition of the experiment taught me the error and the necessity of a different conclusion.

An inspection of columns 6, 7, 10, 11, of Table V, will prove that all previous estimates of the heat set free by a change in the density of air, as well as all supposed natural laws of regular progression, adopted in connection with them, must be inaccurate. This apparent deviation from the general practice of nature admits of an explanation. Variations of pressure, and variations of heat evolved in consequence, follow each other as cause and effect; yet, there is an interference, particularly in respect to äerial bodies, arising from their property of elasticity, which prevents these variations from being equal in different cases. The cause of volume and the cause of elasticity are the same, and this is undoubtedly caloric; and the difference between them is dependent upon a modified affinity for this principle, which appears to increase, in proportion as the pressure the elastic body is subjected to is greater. In consequence of this growing affinity, the tension of air must increase in a much greater ratio than the quantity of heat set free during the reduction of volume.

In the experiments, as recorded, all preconceived notions of a uniform law of progression of any kind were set aside, and nothing were regarded but the quantity and tension of the materials employed, and the indications of the thermometer. The experiments, indeed, show that if there is any precise law of progression, or fixed relation between an increase of tension and the amount of latent heat set free in air by it, it must be in an inverse and rapidly diminishing ratio. Thus, the quantity of heat generated by compressing air to half its volume, is, as shown in columns 6 and 7, sufficient to elevate the temperature of an equal weight of water 74° F. and of its own body 277 degrees F. When it was reduced to one-fourth of its volume the increase of heat became for water 105° F. and for air 395° F.; and when condensed to one-eighth of its original volume, the heat was, for water, 125°, and for air 472° F.

According to these observations and deductions, while the densities of air increased in the geometrical progression 2, 4, 8, the heats evolved corresponded, nearly, to the arithmetical series 3, 4, 5. But the ratio in the differences of temperature between the assigned densities followed a very different rate of progression from either; thus for the densities 2, 4, 8 atmospheric pressures, the corresponding differences of heat evolved were in the decreasing numbers, nearly, (277, 118, 80) 3·5, 1·5, 1.

I deem it highly probable that the foregoing deductions are very near to true expositions of the relations between the condensation of atmospheric air, and the evolution of its latent heat. The discrepancies between the actual observations and the numbers which should belong to a law of progression, are more reasonably to be referred to error in the former than in the latter. A slight examination of the tables will shew how very important it is in such experiments, that the instruments for making observations should be both delicate and accurate. It has been mentioned that the thermometers used could not be relied upon within half a degree of their indications; while an error to this extent would produce a difference in the deductions of the first line of Table V, of one-tenth part and, of course, materially affect the value of the experiment. Besides the necessity of proper philosophical instruments, the series of observations on both densities and temperature ought to have been more extended to justify the attempt to establish a natural law from their deductions. So well aware was I of the importance of an extended succession of observations, that in drawing up the design of the machine, I endeavored to adjust its proportions so that it should be capable of working to a tension of sixteen atmospheres; but on trial, many portions of it were found too weak to sustain such a pressure. I will, however, repeat that such experiments as the machine admitted of being made, have been made under a full conviction of their importance, and with a determination that nothing should be noted which my own senses did not perceive, nor set down but as the result of repeated and confirmed observation; and, notwithstanding the imperfection of instruments and machinery, I am of opinion that they cannot be in error to any considerable extent, nor can I hesitate to recommend them to public confidence.

Apalachicola, March 7, 1850.

ART. XXI.—*Notice of Remains of Vertebrated Animals found at Richmond, Virginia;* by JEFFRIES WYMAN, M. D.

THE remains which are the subject of this notice were discovered in the tertiary beds which form the foundation of the city of Richmond, and which extend beyond its limits over a vast area. Mr. Conrad regarded these beds as identical with the English crag under the name of "medial pliocene," and Professors W. B. and H. D. Rogers describe them under the name of Miocene.* The opinion of these last geologists is confirmed by the observations of Sir Charles Lyell.† Prof. W. B. Rogers informs me in addition that in the bottom of some of the ravines, a stratum exists containing Eocene fossils.

A large proportion of the bones and teeth here described were discovered and exhumed by Dr. Martin Burton of Richmond, in the various ravines which intersect this city and its vicinity, but more especially those at its eastern and western extremity. The largest ravine, the one through which Shockoe creek makes its way into the James River, is about one hundred feet in depth and many hundreds in breadth. From this there branch off on either side many smaller ravines with nearly vertical walls. The most remarkable of these are on the western side. On the eastern slope there are none so deeply cut, but on the bottom of them may be seen a layer of silicious animalcular deposit which was noticed by Profs. Rogers. Prof. J. W. Bailey of West Point, has shown that it contains many species of infusorial forms in vast numbers.‡ This stratum, according to Prof. W. B. Rogers, is near the lower limit of the Miocene in that vicinity.

In the Miocene deposits are found the remains of Vertebrata in great numbers, especially of Sharks and of a small species of Myliobatis. The infusorial stratum and the strata immediately above it contain stones of very small size only, and give no evidence of rapid currents of water or of heavy waves; every thing seems sedimentary in its character. More superficially is a deposit of clay containing casts of Pecten in great abundance, and above this, rounded stones become quite numerous, and are used for the purpose of paving. On the recent removal of a portion of Mayos hill, a stratum of dark blue marine mud was exposed in which were discovered pieces of drift wood, still preserving their general characters, and even their microscopic structure, though so soft and decayed as to yield to very slight pressure from the fingers; its tenacity was so slight that it became difficult to remove the pieces without breaking. In some instances they were perforated with canals similar to those made by the Teredo. If the wood thus discovered were allowed to dry in the open air, as its moisture evaporated, it became more and more solid, and soon assumed the constitution of lignite, having the density, brittle fracture and shining surface of coal. The progress of this change I had an opportunity of noticing in a piece of wood which lay on my table from the time it was exhumed until it was completely converted into lignite. Fruits well preserved were occasionally found, and in one instance a nut which was recognized by Prof. Agassiz as belonging to the genus Carya or hickory. I have as yet seen but very few unequivocal remains of reptiles. These consist of a few teeth which will be noticed in a subsequent portion of this paper. Coprolites have also been found in great numbers some of them of unusual large size.

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* Trans. Am. Philos. Soc., Philad., 1836.

† Proceedings Geolog. Soc., Lond., Feb. 26, 1845.

‡ See Prof. Bailey's several articles in Am. Jour. of Science.

Remains of Mammals.—*Seals.* Among the most interesting of the relics discovered by Dr. Burton were parts of the cranium of an animal belonging to the natural family of Phocidæ, a family of which but few remains had been previously detected, and in so far as I have been able to find any record, only in one other locality in the United States. The bones were fragile, and had evidently been crushed previous to exhumation. The pieces in my possession consist of two temporal bones nearly entire, a fragment including a portion of the parietal and occipital bones, and in addition a part of the base of the skull. The reëntering angle of the occiput, the well marked depressions corresponding with the cerebral convolutions on the parietal bones, the form of the cranial cavity, the deep fossa above the internal auditory foramen, the vascular canals opening on the occiput, and the inflated tympanic bones, all indicated an affinity to the Phocidæ. The size varied but little from that of the common Harp seal, (P. Groenlandica.) The presence of an interparietal crest indicating a large development of the temporal muscles, offers a diagnostic sign by which it may be distinguished from P. barbata, P. Groenlandica, P. hispida, P. mitrata, and P. vitulina. From those species of seals which are provided with a crest the fossil presents a well marked difference in having the mastoid process much larger, more rounded, and prominent, nearly equalling the tympanic bone in size. The entrance to the carotid canal is in full view when the base of the skull is turned upwards. The imperfectly divided canal which lodges the Eustachian tube and the tensor tympani muscle is of remarkable dimensions, especially when compared with that of P. Groenlandica. The interparietal crest extending from the occiput to the anterior edge of the frontals, is most narrow posteriorly where it is but slightly elevated above the surrounding bones.

The fragments of cranium above described were found in the Shockoe creek ravine near the base of Church Hill. In the ravine at the eastern extremity of the city and in the neighborhood of the penitentiary, Dr. Burton obtained several other portions of the skeleton of another seal. These consisted of an imperfect cervical vertebra, a lumbar vertebra nearly entire, a fragment of the sacrum, coccygeal vertebra, fragments of ribs and the lower extremity of a fibula. Their generic characters have been satisfactorily made out by comparisons with recent bones.*

In figure 1, page 232, I have represented the coccygeal vertebra which corresponds in its general characters very accurately with recent bones of P. Groenlandica from the same region of the vertebral column. The small size of the vertebral canal and the imperfect transverse process, the wide spread articulating processes and the blunted spinous process indicate its affinity to the seals.

The fragment of a left fibula (figs. 2 and 3) presents at its lower extremity (fig. 3), an oblique regularly concave articulating surface, on its inner face, and on its outer (figs. 2 and 3,) an elevated ridge or crest on either side of which is a groove for the passage of a tendon.

Phocodon, Agassiz.—Of this interesting genus, (which is so nearly allied with *Squalodon* of Grateloup, *Basilosaurus* of Harlan, *Zeuglodon* of Owen and J. Müller, *Dorudon* of Gibbes, and the remains from which the empirical *Hydrarchos* of Koch was made, I have received from Dr. Burton only a single tooth, which was identified by Prof. Agassiz.†

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* The only other locality for fossil bones of seals which I have seen noticed as occurring in the U. States, is the one mentioned by Dr. C. T. Jackson (in his final Report on the Geology of New Hampshire) at South Berwick, Maine, in marine mud, about thirty feet below the surface, and which were brought to light on digging a well. These were sent to me for description and proved to be an ulna and a radius.

Cuvier in the last edition of the Ossemens Fossiles (t. viii, p. 454) after having set aside many pretended discoveries, says: "en effet rien n'est plus rare que des os de Phoques, et de Lamantins parmis les fossiles." "Je n'ai pu obtenir d'ossemens fossiles de phoques bien' constatés que des seuls environs d'Angers."

The fragments described by Cuvier as belonging to two individuals, were subsequently asserted by Blainville to belong to one and the same bone, and were shown to be those of a Manatee instead of a Seal, a discovery on which M. de. B. dwells with peculiar satisfaction. Osteographie, Genus Phoca, p. 40.)

Among the veritable discoveries of the remains of fossil seals, Blainville cites the following, (Osteograph., Gen. Phoca, p. 41.)

1. Teeth from Maestricht, accompanied with those of sharks. Boué, Journ. de Geol., t. iii, p. 31.

2 Teeth, a vertebra and a cranium, found in Westphalia. Hermann von Meyer, Paleologica, p. 131.

3. Also from the same authority, teeth very similar to those of seals, and of sharks, from Laxberg near Aix la Chapelle.

4. A fragment of an ilium is referred to, described by Eugene Robert, found in the shell tufa of Iceland with Cyprina Islandica and other recent shells. This is probably from an existing species.

5. In the Museum of Perth, Hungary, exists a hind foot, found near Vienna in the valley of the Danube.

† Prof. A. will soon publish a complete memoir, on this genus found in the United States, in which will be given the result of his personal observations drawn from large collections of remains.

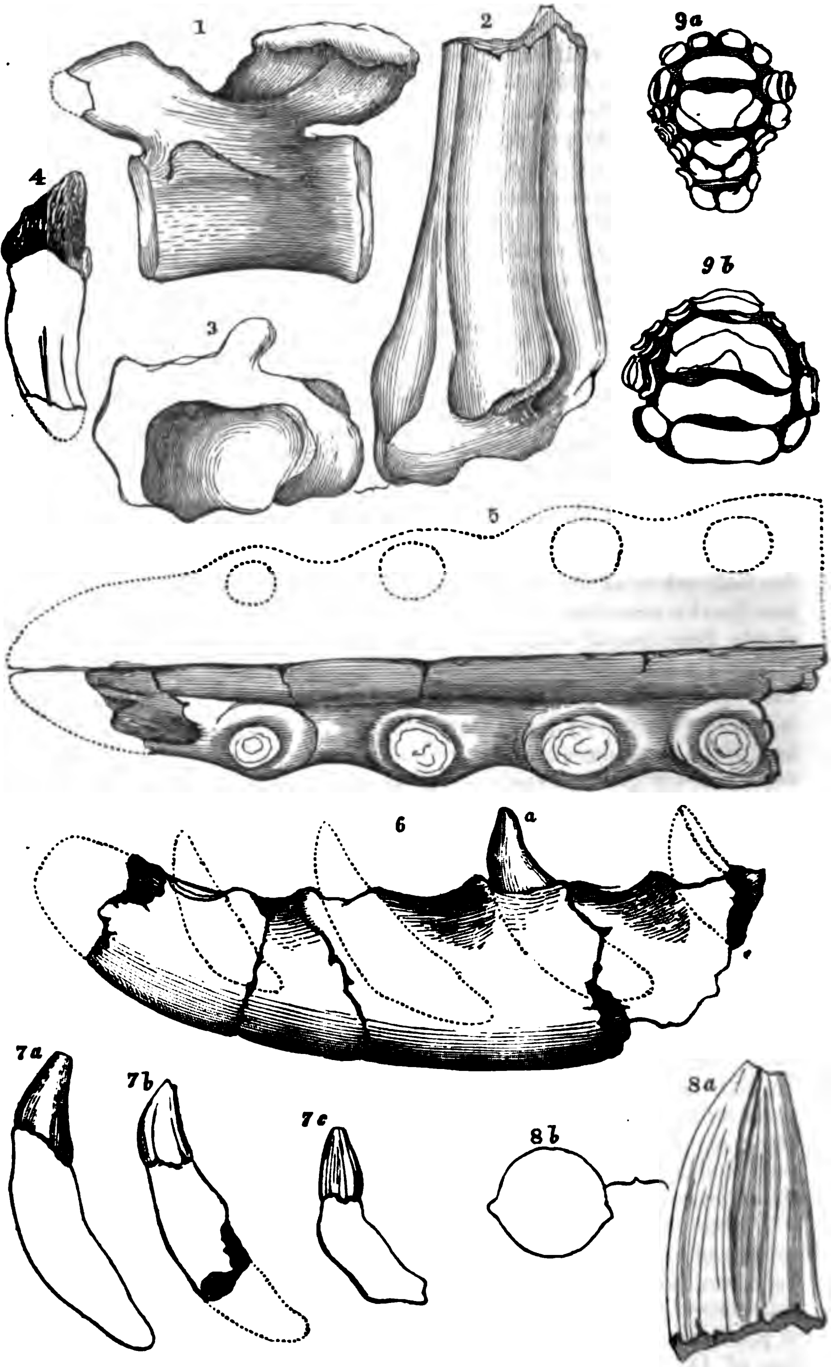
This tooth (fig. 4,) is $1\frac{3}{16}$ inch in length, having a small portion broken from the end of its root. The crown is conical, compressed on its inner face, with slightly trenchant edges, the posterior of which is provided with a slightly projecting tubercle. The enamel over its whole surface is roughened by small irregular ridges, the general direction of which is from the base towards the apex of the crown, those at the apex being the most minute. This tooth must have been placed at the anterior part of the jaw; all those of the posterior lateral portions being deeply indented.

Dr. Burton has also found a petrous bone with its convoluted appendage, which has all the Cetacean characteristics and which Prof. Agassiz likewise refers to the genus Phocodon.

Delphinus.—From the same locality and in the immediate neighborhood of the spot in which the vertebræ and other bones of the seal were found, Dr. Burton obtained four vertebræ all belonging apparently to one individual and nearly of the size of those of the common porpoise, (D. delphis.)

The fragment of a lower jaw represented in figures 5 and 6, if the indications of the teeth are followed, is Cetacean, though the jaw itself is somewhat unusual. The crowns project but slightly above their alveoli, and are small when compared with the roots which are long, bulging near the middle and deeply imbedded in their sockets. The extent to which they penetrate into the jaw is made obvious by three fractures, which intersect the alveoli near their termination. A reptilian feature in the jaw may be recognized in the depressions or grooves which exist on its sides in the intervals between the teeth, as if for the reception of the teeth of the upper maxillary bone, a condition which Dr. R. W. Gibbes has shown to exist in the Basilosaurus. Each tooth is surrounded by a distinct circular ridge. The teeth are solid, the pulp cavity being wholly filled up. By reference to figure 5 it will be seen that the two halves of the lower jaw are united through the whole extent of this fragment (the symphysis) by a flat surface as is the case in the sperm whales and in the Gavials among Crocodiles. It differs however from the latter in the absence of an enlargement of the jaw at its extremity, (gradually diminishing to a point as in Cetaceans,) as well as in the deficiency of teeth of larger dimensions which in Gavials correspond to canines. Were it not for the prolonged symphysis the jaw might be regarded as belonging to the genus Phocodon. In its symphysis it closely resembles that of some species of Delphinus.

The teeth represented in figure 7, are regarded as belonging to an animal of the same species as the jaw above described, presenting the same form of the crown and root represented at *a* figure 6, the only one which was preserved entire. These teeth are either solid or provided with only a minute pulp cavity. This jaw resembles that of Delphinus more closely than that of any other Cetacean.


1
2
9a
4
9b
3
5
6
a
7a
7b
7c
8b
8a

This fragment I found in one of the small ravines on the western side of the Shockoe Creek Ravine.

In one of the species of Zeuglodon figured by Müller, there exists a lower jaw with a prolonged symphysis as in the above specimen, though the teeth of the first are less numerous. He also figures a portion of an upper jaw which is turned up, presenting a convexity corresponding with the concavity of the outline of the lower fragment here described. Fig. 6.

In addition to the above, there have been found from time to time for many years, fragments of bones of the larger Cetaceans of which I have numerous specimens, but have seen none of the dimensions of those of the largest existing whales. Their specific characters have not been recognized. I have a single imperfect tooth nearly five inches in length, the crown of which is quite small compared with the root, and its surface is irregularly striated or reticulated as in the figures of the teeth of Zeuglodon, given by Johannes Müller in his memoir on this last animal.

Reptiles.—The only remains which represent this order are teeth, one of which is represented in figure 8*a* of its natural size and which is obviously that of some species of Crocodile. Its form is blunt conical, with a transverse section nearly circular, and having on each side a small and well defined ridge largest at its upper extremity and terminating below in a delicate point. The surface of the tooth is marked with minute longitudinal striæ. The lateral ridges divide the tooth into two unequal portions as shown in the section, figure 8 *b*.

Some of the teeth of one other species of reptile allied to the Crocodiles was found in company with the preceding, but which differ from the described forms in having the whole surface covered with well defined longitudinal flutings extending from the base to the apex—similar to those of Mosasaurus; but the tooth is without an enlarged base.

The precise locality from which these Reptilian teeth were obtained, I am unable to state; they were from the tertiary deposits.

Fishes.—Of all the remains found in this locality, those of fishes are by far the most numerous, and of these the largest portion belong to the Plagiostome group, and will therefore be almost necessarily represented by the teeth alone. As nearly all the genera and species have been previously described, a catalogue of them will be all that is necessary.

Lamna compressa, Agass.
L. acuminata, Agass.
L. crassidens, Agass.
L. elegans, Agass.

All of these have been found in the Eocene beds of S. Carolina by Dr. R. W. Gibbes. The specimens above enumerated were found in digging wells in Richmond, but whether from Eocene or Miocene beds I am unable to state.

Otodus appendiculatus, Agass.
O. lineatus.
O. obliquus, Agass.
O. lanceolatus.
Oxyrhina hastalis, Agass.
Ox. xiphodon, Agass.
Hemipristis serra, Agass.
Carcharodon angustidens, Agass.
Galeocerdo contortus, Gibbes.
G. Egertonii, Agass.
Sphyrna lata, Agass.
Glyphis subulata, Gibbes.

Notidanus primigenius. This species is quite rare. The specimen here referred to is the only one which I have seen mentioned as coming from the U. States. This was described by Dr. R. W. Gibbes in his memoir on the fossil Squalidæ *

Genus Myliobatis.—After the genus Lamna, Myliobatis may be mentioned as the one which furnishes the largest number of remains.

Genus Phyllodus.—The palatine or pharyngeal plates, fig. 9 *a* and *b*, were found by Dr. Burton, and as I believe as far as any record appears to the contrary for the first time in the U. States. Of this remarkable genus first described by Agassiz, nothing has yet been discovered but the plates similar to those represented by the figures. Each of the central plates consists of a series of superimposed layers. Agassiz† and Owen‡ have given the details of their microscopic structure. All the species enumerated by Agassiz, six in number, were found in the London clay of Sheppey. Fig. 9 *a* resembles P. toliapicus. Fig. 9 *b* does not resemble any of the species figured in the Poissons Fossiles, but is imperfect. Owen regards Phyllodus as allied to Scarus, but Agassiz does not admit the correctness of this opinion.

Genus Pogonias.—The peculiar pharyngeal teeth of these fishes have been several times discovered, and I have recently received from Dr. Burton broken specimens of large size.

Vertebræ of fishes.—These exist in great numbers, but almost invariably disjointed. I have no means of determining them. Some few have the elongated bodies of the Scomberoids.

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* Nearly all the names given above were furnished me by Dr. Gibbes. For a full description of the genera and species here enumerated, his valuable memoir can be referred to as containing the most complete description as yet given of the fossil Squalidæ the U. States. See his Memoir, Jour. Acad. Nat. Sciences, Philadelphia, 1849.

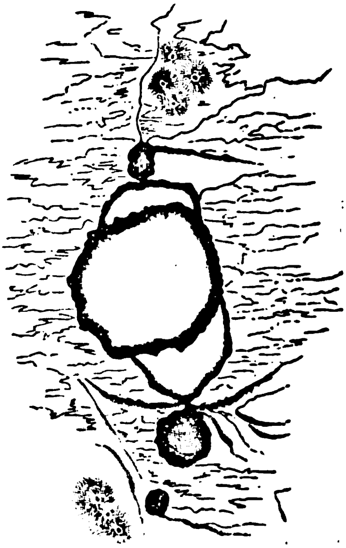
† Poissons Fossiles, t. ii, p 288.

‡ Odontography.

Coprolites.—Of numerous specimens of these remains, there is one of unusual dimensions. It is six and a half inches in length and three inches in diameter. It presents indications of having been moulded upon a spiral membrane; its fractured surface exhibits fragments of bone and something resembling the scales of fishes. The color of the fractured surface is of a reddish brown.

Art. XXII.—*On the Volcanic Eruptions of Hawaii;* by James D. Dana—Continued from vol. ix, p. 364.

In a former article, a historical account was given of the eruptions of Kilauea, the great pit-crater on the flanks of Mount Loa, situated at a height of about 4000 feet above the sea. The following pages contain what information we have collected respecting the summit eruptions of Mount Loa.* The crater is a deep pit in the very summit of the mountain dome, and is called by the natives Mokua-weo-weo.† It has nearly an elliptical figure, as shown in the annexed cut, with its diameters 13,000 and 8000 feet respectively, the longer lying in a north-by-west and south-by-east direction. But the deep part of the crater is nearly circular, and has the breadth of the smaller diameter, the northern and southern portions being shallow. The walls, through a considerable portion of their circuit, are abrupt or even vertical, and are stratified in structure like the sides of Kilauea; on the west side the height was found by Henry Eld, Jr., to be seven hundred and eighty-four feet, and on the east four hundred and seventy feet.



The bottom of the pit when examined by Captain Wilkes and the officers of the Vincennes, consisted of solidified lava, through which there were several fissures and fumaroles emitting steam and sulphur vapors in large volumes. Some parts were rough with clinkers, while in others, smoother tracts of solid lava constituted the surface. The fissures had in general a north-northwest and south-southeast direction, and one near the west bank had ejected lavas at no distant period. Two cinder cones at the bottom, consisting of light scoria, were remarkably perfect in form, and one was two hundred feet high. About many of the fumaroles there were the same salts that occur at the sulphur banks of Kilauea.

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* The summit crater was examined and thoroughly explored by Captain Wilkes and the officers of the Vincennes, and a detailed account of it is given in the fourth volume of the Narrative of the Expedition. The above sketch is a reduced copy of that in the Narrative, p. 111. The author's explorations did not reach above Kilauea, his time having been limited by orders to other groups of Islands.

† The name of the crater is pronounced *Mokooah-wayo-wayo.*

Besides the large pit there were two others, one on the north, and another (called Pohakuo-hanalei) on the south, both of which may be looked upon as subordinate to the central crater, as they are enclosed within the same general rim or outline. There is also another small pit, distinct from these, a short distance to the south.

Into Pohakuo-hanalei, a stream of lava had run from Mokua-weo-weo, and Capt. Wilkes remarks that it looked like a cascade of iron which had become solid before reaching the bottom. There were several deep fissures in the vicinity of this pit, and every appearance of recent eruptions. "The lava at the mouth of some of the chasms appeared as though it had been thrown up and plastered on the edges in clots, which seemed of the consistency of tar or melted sealing-wax of various colors, the most predominant a dark brown."

There were several small cones about the summit, both to the north and south of Mokua-weo-weo.

The rocks of the summit, where there was evidence in their appearance of recent origin, resembled those of modern ejections below. But the walls of the crater are described as consisting of a compact grayish rock without cellules and often breaking in plates. The specimens obtained were a grayish clinkstone speckled with a white feldspar, with no trace of a cellule, and no resemblance to ordinary lavas. They consisted mostly of the feldspar.

But little is known with regard to the eruptions of the summit crater. Yet there is abundant evidence that, even at the present time, its fires are not entirely inactive.

An eruption is stated to have taken place on the 20th of June, 1832, and the mountain continued burning for two or three weeks; the lavas broke out, in different places, and were discharged from so many vents, that the fires were seen on every side of the dome, and were visible as far as Lahaina, upwards of one hundred miles.*

The first ascent to the summit of Mount Loa by a foreigner was made by Dr. Douglass. This author describes it as far surpassing Kilauea in sublimity and violent activity. Mr. Douglass's observations are, however, received with incredulity by the residents. The crater, if thus active, would, like Kilauea, have shown evidence of it in an illuminated cloud at night. But neither this nor any other proofs of its action were noticed at the time by the Hawaiians or by the whites residing among them.*

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* See this Journal, volume xxv, 201, in a communication from Rev. J. Goodrich, dated Nov. 17, 1832.

An eruption took place in January, 1843, which is described by Messrs. Andrews and Coan.† It broke out at the summit, on the 10th of January, and continued down the slopes of Mount Loa in two streams; one flowed to the westward towards Kona; the other flowed northward to the foot of Mount Kea, and then dividing, one part continued on towards Waimea northeastward, and the other towards Hilo, eastward.

We cite here the account given by the Rev. Mr. Coan of the American Mission at Hilo on the eastern shore, who has spent much time in his many explorations of Mount Loa.

"On the morning of January 10th, before day, we discovered a small beacon fire near the summit of Mauna Loa, directly in the rear of our station, about thirty miles distant. This was soon found to be a new volcano, bursting out on the northeastern slope of the mountain, at an elevation of near 13,000 feet. From this time, the eruption increased in magnitude and intensity, from day to day, till it presented a scene of sublime splendor, disgorging vast columns of fiery fluid which rolled in a broad, burning river down the side of the mountain. Subsequently the lava appeared to burst out at several different points lower down the mountain, from whence it flowed off in the direction of Mauna Kea, filling the great valley between the mountains with a sea of fire, and throwing a broad sheen of light upon the heavens. Some of our nights have presented scenes sublimely grand and fearfully magnificent. The position of the eruption is such that it can be distinctly seen from the window of our dormitory, so that we can lie on our couch and watch the fantastic and ever varying action of the fires from evening to morning. The rapid disgorgement of the gory flood, the lofty rising of brilliant pillars—like burning brass—the irregular shooting of coruscations, and the fearful flow of the molten sea—all tend to excite a wakeful spirit, and incline us sometimes to keep vigils for most of the night. For about four weeks, this scene continued without much abatement. At the present time, after six weeks, the action of the fire is greatly diminished, though it is still somewhat vehement at one or two points along the line of eruption. The flow of the lava has probably extended twenty miles. As to its breadth and depth, we can form no opinion at this distance. We apprehend that the fires have nearly spent their force, though in this we may be mistaken."

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* A comparison of the statements in the following paragraph by Mr. Douglass, with the observations by the officers of the Vincennes, will show that this incredulity is probably not misplaced. "The mountain (Mount Loa), with an elevation of 13,517 feet, is one of the most interesting in the world. The journey to the top took me seventeen days. On the summit is a volcano, nearly twenty-four (?) miles in circumference, and at present in terrific activity. You must not confound this with the one situated on the flanks of Mauna Roa, and spoken of by the missionaries and Lord Byron, and which I visited also. It is difficult to attempt describing such an immense place. The spectator is lost in terror and admiration at beholding an enormous sunken pit, (for it differs from all our notions of volcanoes as possessing cone-shaped summits with terminal openings,) five miles square of which is a lake of liquid fire, in a state of ebullition, sometimes tranquil, at other times rolling its blazing waves with furious agitation, and casting them upwards in columns from thirty to one hundred and seventy feet. This volcano is 1272 feet deep; I mean down to the surface of the fire; its chasms and caverns can never be measured." Extracts from the Journal of Mr. Douglass, Magazine of Zoology and Botany, 1837, i, 582.

† Missionary Herald, xxxix, 381, 463; and xl, 44. The course of the stream, and its origin were particularly examined by the Rev. T. Coan.

[On Monday the 6th of March, Mr. Coan, in company with Mr. Paris and seven natives, left Hilo on their tour of exploration.]

"We did not take the usual route—that pursued by Captain Wilkes and others, via Kilauea—but directed our course at once for the stream of lava, as it was seen flowing on the high plains between Mauna Loa and Mauna Kea. Our general course was west-south-west, through a vast forest, so interwoven with jungle as to render it in most places impenetrable. As the season was peculiarly dry, we chose for our path the rocky bed of a river, called the River of Destruction, from the quantity and rush of its waters during the rainy seasons. The stream was now so low that we could pass up its bed and under its banks by leaping from rock to rock, and frequently crossing from side to side, now and then also ascending its banks and beating our way for a short distance through the brushwood, to avoid deep water, perpendicular precipices, or the accumulated masses of drift-wood. These drift wood accumulations consisted often of majestic trees which had been torn violently from their places, and, with roots, trunk, and branches, carried down the stream to some narrow pass, where their progress was arrested by the approaching banks, by vast rocks, or by a sudden bend in the stream, so as to form an impregnable chevaux-de-frise against the traveller.

[The night was spent by Mr. Coan and his party in the outskirts of the forest already mentioned.]

On the second day, we again entered the bed of the stream, and pursued our romantic course along the serpentine and rocky channel, and between its precipitous and often overhanging banks, which sometimes presented frowning battlements of dark naked lava, and sometimes retreated in graceful slopes of luxuriant soil, adorned with trees, shrubs, vines, and parasitical plants, or spread with a splendid carpet of soft velvet moss. In this lofty and deep forest, and amid these everlasting solitudes—unbroken except by the gurgling of the wasted stream, the dashing of the cascade, or the mighty rush and the deep thunder tones of the mountain torrent, and, I should add, by the enchanting strains of the ten thousand songsters whose notes seemed to fill every leaf and shrub and tree with animated joy—we pursued our quiet way till the outstretching shades of evening admonished us to prepare for repose.

[The night was passed in a booth of boughs and ferns, erected for the emergency on the bank of the river.]

Early the next morning, we pursued our way up the stream, and at noon found ourselves fairly out of the forest with the lofty summit of Mauna Kea rising in hoary grandeur before us. We were now at its base, and in the high, open country occupied by herds of wild cattle. We bent our course south-south-west, over a beautiful rolling country, sprinkled here and there with clumps of low, spreading trees, which looked like orchards in the distance. Our way was along the upper skirts of the forest, having Mauna Kea with its numerous peaks and lateral craters on our right. At evening we came in full view of Mauna Loa, bearing south by west from us. We pitched our tent under an ancient crater, four hundred feet high, now covered with trees and grass.

Here we had a splendid view of the great terminal crater on the summit of the mountain, about twenty-five miles distant, and also of the vast flood of lava which had flowed down the northern side of the mountain to the plains below, some part of which lay burning at our feet, at the distance of four or five miles. We were now seven or eight thousand feet above the level of the sea; and we could see the dark clouds gather, and the lightnings blaze below us, while the deep toned thunder rolled at our feet. At the same time, a storm of hail spread along the shore and fell upon the station at Hilo. This was the first hail seen at our station since our arrival at the Islands. At twilight a smart shock of an earthquake, which lasted thirty seconds, added to the sublimity of the scene; while a blazing comet hung over us in the vaulted sky. As darkness gathered around us, the lurid fires of the volcano began to glow with fervid heat, and to gleam upon us from the foot of Mauna Kea, over all the plain between the two mountains, and up the side of Mauna Loa to its snow-crowned summit, exhibiting the appearance of vast and innumerable furnaces, burning with intense vehemence, and throwing out a terrible radiance in all directions. During the night we had thunder and lightning; and in the morning both mountains were beautifully mantled in snow.

It was now Thursday, and we left our encampment and proceeded three or four miles towards the new stream of lava, and again pitched our tent on the side of an old crater, two hundred feet high and one mile in circumference, and covered with trees and shrubbery to its summit. It was surrounded at its base, however, by a vast field of naked scoria of the most jagged character, the deposit of some former eruption which had flowed around the little fertile hill, and left it like an island in the ocean, or like an oasis in the desert. Leaving our natives to prepare our encampment and collect fuel, water, etc., we set off for the nearest stream of active lava, distant about two miles. Our road was over sharp jagged lava, thrown up in tumultuous confusion; but we soon made our way to the molten stream, and, thrusting our staffs into the viscid mass, took out and cooled specimens which we carried home with us. You will understand that we were now on the great plain between Mauna Loa and Mauna Kea, about 7,000 feet above the level of the sea, not having as yet commenced the direct ascent of the mountain. On this plain, between the bases of the two mountains, we spent the day in traversing and surveying the immense streams of fresh scoria and slag, which lay smouldering in wild confusion farther than the eye could reach,—some cooled, some half-cooled, and some still in a state of igneous fusion. The scoriform masses which formed the larger portion of the flowings, lay piled in mounds and extended in high ridges of from thirty to sixty feet elevation above the substratum on which it rested, and forming a barrier so indescribably jagged and rough as to be nearly impassable. It seemed as if this vast sea of earthy and rocky fusion had been suddenly solidified, while in a state of the most tumultuous action. Besides these high and broad ridges of scoria, there were parallel streams of slag, solidified on the top, like ice on a river. This was smooth, of lustrous black, and in a vitrescent state, forming the superincumbent crust of a deep molten river which rolled beneath, and which betrayed its burning course at innumerable cracks and seams and blow-holes, in which the fiery fluid was seen, or through which it was expelled in gory jets.

We spent the whole day in exploring this vast sea of lava, and were astonished at its immense area. In rolling down the side of the mountain, one broad stream had shot off in a westerly direction, towards Kona. Another mighty river had flowed northward till it was intercepted by the base of Mauna Kea, when it divided into two branches, one flowing in a north-west direction towards the plains of Waimea, and the other arm stretching north-east and flowing towards Hilo. These three main branches, if united, would form probably a river five or six miles broad; and the longest of them cannot I think, have advanced less than twenty-five or thirty miles. They are still flowing, but their progress at present is slow, as they are on a vast plain, and their celerity is also retarded by fissures and caverns, and by fields of old scoria which covers those high regions. Should the eruption continue, and should the quantity of fusion be sufficient to overcome the obstacles and reach the regions where the face of the country declines rapidly towards the sea, the descent will then be quick and easy to the coast, both on the eastern and western shores. This may take place though I am rather of the opinion that the fires will have spent their force before they reach the sea.

Besides the three great branches described, there are numerous smaller ones, shooting out laterally and irregularly from the main streams, both on the side and at the base of the mountain. These form together an indescribable labyrinth.

After travelling hard all day, without being able to reach the extreme ends of the two great western branches of the eruption, we returned at evening to our tent, weary, but gratified nearly to oppression by the vastness and the terribleness of the scenes we had witnessed.

[During the night, a dense, dark cloud invested the eminence on which the travellers had encamped; this was charged with electric fluid, which soon began to blaze around them with terrific splendor, accompanied, at the same time, with startling peals of thunder. They felt that they were "in a sea of electricity;" and realized the sublimity of the expression, "The God of Glory thundereth." At length the storm passed away, and the volcanic fires which had been concealed by the tempest, "resumed their merry dance, spouting forth their gory masses in fantastic and ever varying forms, at different points, from mountain to mountain, along the whole line of eruption."]

Ascent to the Crater.—The next morning we rose early, and made our preparations for visiting the summit of the mountain, distant about twenty miles. As we did not suppose it possible to reach the summit and return to our camp the same day, we provided ourselves with caps, flannels, mittens, cloaks, comfortables, etc., for sleeping upon the lava on the side of the mountain; and taking a little food and a calabash of water, we committed our luggage to two strong natives, leaving the rest of our company where we had encamped during the night. Thus prepared we set off, expecting to spend two days upon the mountain. Our way at first lay over a field of scoria of an indescribably sharp and jagged character; and we had not proceeded more than half a mile before we found that the two natives who carried our clothing fell in the rear, and followed us at the rate of less than a mile an hour,—the road being so inconceivably rugged that they could not quicken their pace without being in danger of stumbling at every step, and breaking their calabashes, and tearing their flesh. We halted suddenly, held a short consultation, set down our calabashes on the lava, took a little biscuit in our pockets, laid our cloaks and umbrellas on our guides, and leaving everything else behind, set out again for the summit of the mountain. After passing this tract of scoria, we came to a field of more compact and smooth lava, lying along the borders of the new stream. Here we moved on rapidly, at the rate of three and a half or four miles an hour. As we had left most of our clothing and food, with all our water, behind, and as we clung to the hope of reaching the original point of eruption—a vast, active crater, within a few hundred feet of the highest part of the mountain—we felt it necessary to press hard and improve every moment, as we must return the same day, or probably perish with cold amid those high regions of snow and tempests.

To describe our road would be tedious, if not impossible. Sometimes we were on ancient deposits and sometimes on the new; sometimes on broad fields of smooth, shining lava, and sometimes crossing extended tracts of the sharp, spurry kind before mentioned; now we were climbing a high ridge of loose scoria and slag, and then feeling our way down a ravine amidst poised and pendant masses that seemed to say, "Touch us not lest we bury you from the light of day."

At ten o'clock we were fairly at the foot of the mountain proper, and began a more regular and rapid ascent, though we had been gradually rising for an hour or two before. The new streams of lava, spread to the breadth of several miles over the side of the mountain, for the most part were nearly cooled; in many places, however, they were burning hot, and emitting smoke, steam, and pungent gases.

At noon we lost sight of our native attendants, who were unable to keep up with us in our rapid and forced march, and we saw them no more during the day. We were now on the new eruption, and our ascent became more and more steep; while the rarity of the atmosphere affected our respiration, so that it was difficult to proceed many rods without stopping to pant and recover breath. The lava on which we were treading gave indubitable evidence of powerful igneous action below, as it was hot and full of seams, from which smoke and gas were escaping. But we soon had ocular demonstration of what was the state beneath us; for in passing along we came to an opening in the superincumbent stratum, of twenty yards long and ten wide, through which we looked, and at the depth of fifty feet, we saw a vast tunnel or subterranean canal, lined with smooth vitrified matter, and forming the channel of a river of fire. which swept down the steep side of the mountain with amazing velocity. The sight of this covered aqueduct—or if I may be allowed to coin a word, this *pyroduct*—filled with mineral fusion, and flowing under our feet at the rate of twenty miles an hour, was truly startling. One glance at the fearful spectacle was worth a journey of a thousand miles. We gazed upon the scene with a kind of ecstasy, knowing that we had been travelling for hours over this river of fire, and crossing and recrossing it at numerous points. As we passed up the mountain, we found several similar openings into this canal, through which we cast large stones; these instead of sinking into the viscid mass, were borne instantly out of our sight upon its burning bosom. Mounds, ridges, and cones were also thrown up along the line of the lava stream, from the latter of which, steam, gases, and hot stones, were ejected into the air with terrible hissings and belchings.

We had proposed to commence our return at one o'clock in the afternoon; but the hour came and we were still far from the summit. We then added half an hour to the ascent. This passed, but we had not reached the end of our journey. We went on adding half hour to half hour till three o'clock, at which time we reached the verge of the great crater where the eruption first took place, near the highest point of the mountain. This was in the region of perpetual snow; and to reach it we had passed through snow for the last three miles. Here we found two immense craters close to each other, of vast depth and in terrific action; but we had not a moment left to stay and survey them minutely. Kneeling, therefore, among these awful scenes to bless the Hand which had led us thus far, and to ask protection on our return, we turned our faces down the mountain.

Though weary and way-worn, almost to the last degree, we felt that we must regain our tent, long lost in the distance, or run the hazard of perishing upon the mountain. We ran, walked, clambered, descended, stumbled, feeling unable at every step to drag one foot after the other, and yet necessity impelled us to proceed. At length night came on; we were still in a trackless waste of frowning lava, not less than eight or ten miles from our camp. But by the cheering aid of a moon in her first quarter, we could still trace the distant outlines of the green hill on which our cottage of branches stood. We plodded on, alternately walking and resting, at rapid intervals, until a fog came on us shutting out at once the hill, the heavens, and even the volcanic fire from our sight. We could not now keep our course, as we could not see our compass. We wandered some, but not far from the track. Still there was little hope that we should reach our camp.

In about an hour, however, the fog dispersed, the moon and stars looked benignantly upon us, and the volcanic fires began again to play on our left; and after persevering toil, with indescribable weariness, we reached our tent a few minutes before eleven at night. I need not say that our thirsty, exhausted, and lacerated frames welcomed rest and refreshment; nor that our thankful spirits felt untold satisfaction in view of the wondrous scenes we had witnessed during this laborious and eventful day."

[On the following morning, Messrs. Coan and Paris, with the natives who accompanied them, set out upon their return to Hilo.]

In a letter subsequently received by the author from Mr. Coan he states:—"The angle of descent down which the lavas flowed from the summit to the northern base of Mauna Loa is 6°; but there are many places on the side of the mountain where the inclination is 10°, 15°, or 25°, and even down these local declivities of half a mile to two miles in extent, the lava flowed in a continuous stream. This was the fact not only during the flow of several weeks upon the surface, but also in that wonderful flow in the subterranean duct, described in the Missionary Herald. There was no insurmountable barrier in the way of the flow from the summit of Mauna Loa to the base of Mauna Kea, a distance of twenty-five or thirty miles. The stream sometimes struck mounds or hillocks, which changed its course for a little space, or around which it flowed in two channels, reuniting on the lower side of the obstacle, and thus surrounding and leaving it an island in the fiery stream. Ravines, caves, valleys, and depressions were filled up by the lava as it passed down the slope of the mountain, and between the two mountains. In conclusion, I remark, that the stream was continuous for more than twenty-five miles, with an average breadth of one and a half miles, and flowed down a declivity varying from 25° to 1°."

The quiet character of the eruptions of Kilauea was remarked upon in a former article. It is still more surprising that an outbreak of such magnitude as that just described should have taken place, without warning to the islanders.—From a height of 14,000 feet, lavas break out, in a copious flow, and for 25 miles there is a rending of the mountain, and continued ejections; and yet there are none of the terrible convulsions and heavings and darkening showers of ashes or cinders that accompany the eruptions of many smaller volcanoes: there is not even a grumbling beneath to suggest alarm; the first indication was the discovery of what appeared to be a small "beacon fire" near the summit of the dome.

During all this time, Kilauea, on the flanks of the mountain at a level 10,000 feet below, was in its usual active condition, and as an observer says, it showed not the least signs of sympathy. The crater is an opening 3½ miles in length; and within it, an area 1500 and 1000 feet in its diameters, was at the time in constant undisturbed ebullition.

Since 1843, there has been another eruption from the summit, and we look for an early account from the island to give our readers. It took place the past year, and was as remarkable as that described for its quietness of progress, and its extent.

Art. XXIII.—*Mineralogical Notices.**

I. New Species.

1. **Tritomite,** (S. H. Weibye and N. J. Berlin, Pogg., lxxix, 299, 1850.)—Crystals tetrahedral; surfaces smooth and having a reddish crust; cleavage indistinct. Lustre submetallic vitreous. Color dull brown; streak dirty yellowish-gray. Translucent only on the edges. H. between feldspar and apatite. G. = 4·16—4·66. B.B. becomes white, intumesces somewhat, and sometimes decrepitates. In a matrass yields water and gives a weak fluorine reaction. With borax dissolves to a reddish yellow glass, which is colorless on cooling. With muriatic acid, when pulverized, yields chlorine and gelatinizes. *Composition* according to N. J. Berlin, (specific gravity of specimen, 4·24.)

$\dddot{\text{Si}}$	$\dddot{\bar{\text{A}}}\text{l}$	$\dddot{\bar{\text{C}}}\text{e}$	$\dddot{\bar{\text{L}}}\text{a}$	$\dot{\text{Y}}$	$\dot{\text{C}}\text{a}$	$\dot{\text{M}}\text{g}$	$\dot{\text{F}}\text{e}$	$\dot{\text{N}}\text{a}$	Mn, Cu, Sn, W,
20·13	2·24	40·36	15·11	0·46	5·15	0·22	1·83	1·46	4·62

loss by ignition 7·86 = 99·44.

The production of chlorine on heating with muriatic acid shows that the mineral contains the cerium either wholly or in part, as peroxyd. The mineral appears therefore to be a hydrous silicate of the peroxyds of cerium and lanthanum and of lime.

This mineral is from the island of Lamö near Brevig in Norway, and occurs with leucophane and mosandrite in a coarse syenite.

2. **Catapleiite,** (Weibye and Sjögren, ibid.)—Probably monoclinic; found only in imperfect prismatic crystals of 120° nearly, showing sometimes traces of other vertical faces. Cleavage basal, perfect. Surfaces smooth, with little lustre; on fracture, weak vitreous. Color light yellowish brown. Streak isabella-yellow. Opaque. H. near that of feldspar; G. = 2·8. B.B. in the platinum forceps fuses easily to a white enamel; with borax dissolves with difficulty to a clear colorless glass; cobalt solution colored blue. Dissolves easily in muriatic acid, when pulverized, without gelatinizing. Composition according to Sjögren:—

	$\dddot{\text{Si}}$	$\dddot{\bar{\text{Z}}}\text{r}$	$\dddot{\bar{\text{A}}}\text{l}$	$\dot{\text{N}}\text{a}$	$\dot{\text{C}}\text{a}$	$\dot{\text{F}}\text{e}$	$\dot{\text{H}}$
1	46·83	29·81	0·45	10·83	3·61	0·63	8·86
2	46·52	29·33	1·40	10·06	4·66	0·49	9·05
Oxygen,	24·15	7·72	0·65	2·58	1·33	0·11	8·04

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* In the writer's treatise on Mineralogy (third edition), which left the press in May last, the science of Minerals is posted up, as far as could be done in this country, to the time of its publication. The author proposes to continue his appendix to that work in this Journal, giving in each volume an abstract of all the mineral information which has been received through the different foreign and American publications. J. D. D.

Whence for the protoxyds, peroxyds, silica and water, 4·02 : 8·37 : 24·15 : 8·04 = 1 : 2 : 6 : 2, giving the formula

$$3(\dot{\mathrm{Na}}, \dot{\mathrm{Ca}})\,\dddot{\mathrm{Si}} + \bar{\mathrm{Z}}\mathrm{r}^{3}\,\dddot{\mathrm{Si}}^{3} + 6\dot{\bar{\mathrm{H}}}.$$

The earth called zirconia was proved to be identical with the zirconia of the Fredericksvärn zircon. Whether it may not be the allied earth Noria, it is at present difficult to determine.

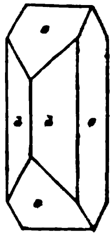
This mineral is associated with the Tritomite.

3. **Atheriastite**, (Weibye and Berlin, ibid.)—Dimetric. In square or eight sided prisms terminating in a pyramid having the terminal angle 135°. Cleavage lateral, perfect, surfaces even and smooth, but not shining. Color verdigris-green, commonly somewhat dirty; streak greenish-gray. Opaque. Fracture uneven and splintery. B.B. in the forceps intumesces, and fuses easily to a dull brown glass. In fine powder slightly decomposed in muriatic acid. Composition according to Berlin:—

	$\dddot{\mathrm{Si}}$	$\dddot{\bar{\mathrm{A}}}\mathrm{l}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\bar{\mathrm{H}}}$
	38·00	24·10	22·64	2·80	4·82	0·78	6·95
Oxygen,	19·73	11·25	6·47	1·10	1·07	0·17	6·22

This gives for the oxygen of the protoxyds, peroxyds, silica and water, 8·81 : 11·25 : 19·73 : 6·22, whence the author deduces the formula $4\dot{\mathrm{R}}^{3}\,\dddot{\mathrm{Si}} + 5\dddot{\bar{\mathrm{A}}}\mathrm{l}\,\dddot{\mathrm{Si}} + 9\dot{\bar{\mathrm{H}}}$, or, as more probable, $2\dot{\mathrm{R}}^{3}\,\dddot{\mathrm{Si}} + 3\dddot{\bar{\mathrm{A}}}\mathrm{l}\,\dddot{\mathrm{Si}} + 4\dot{\bar{\mathrm{H}}}$. From an iron mine near Arendal, in granite with black garnet and Keilhauite. It had been taken for scapolite. [Is it not still possible that the mineral may be an *altered* scapolite? The angle of the pyramid of scapolite is 136°, which is very near that given for the Atheriastite.]

4. **Eudnophite**, (Weibye, von Borck, and Berlin, ibid.)—Trimetric. Crystals rhombic prisms of about 130°; *o* : *d* = 130°*. Cleavage, basal perfect; diagonals less perfect. Cleavage face somewhat pearly. Also granular massive, and sometimes having a feathery arrangement. Color white, to gray or brown. Subtranslucent to translucent. H. = 5·5. G. = 2·27. B.B. fuses to a clear colorless glass. Pulverized forms a jelly with muriatic acid. Composition according to von Borck and Berlin:—



	$\dddot{\mathrm{Si}}$	$\dddot{\bar{\mathrm{A}}}\mathrm{l}$	$\dot{\mathrm{Na}}$	$\dot{\bar{\mathrm{H}}}$
1	54·93	25·59	14·06	8·29 = 100·87
2	55·06	23·12	14·06	8·16 = 100·41

This gives the formula of analcime, $\dot{\mathrm{Na}}^{3}\,\dddot{\mathrm{Si}}^{2} + 3\dddot{\bar{\mathrm{A}}}\mathrm{l}\,\dddot{\mathrm{Si}}^{2} + 6\dot{\bar{\mathrm{H}}}$, and the compound is therefore dimorphous. Found with leucophane on the island of Lamö, Norway, in syenite.

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* The angle between *d* and *e* is given at 120°; and if this be right the vertical prism (*d* : *d*) must also have an angle of 120°.—D.

5. **Dillnite**, ***associated with Diaspore***, (A. Hutzelmann, cited in Pogg., lxxviii, 575, from the Bulletin of the Freunden der Naturwiss. in Vienna.)—There are three substances forming together the gangue of the diaspore of Schemnitz:—One (*A*) is gray, slightly greenish, with a weak greasy lustre and faint translucence; H.=2·5–3·0; G.=2·735. A second (*B*) is white, opaque, with an even and flat conchoidal fracture, and firm; H.=3·5; G.=2·835. Adheres a little to the tongue. A third (*C*) is white, opaque, earthy; H.=1·8—2·0; G.=2·574. Adheres strongly to the tongue. The first and third have been analyzed by Karafiat, the second by Hutzelmann, as follows:

	$\dddot{\mathrm{Si}}$	$\bar{\dddot{\mathrm{Al}}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{K}}$ & $\dot{\mathrm{Na}}$	$\dot{\bar{\mathrm{H}}}$
A.	49·50	27·45	5·56	0·72	1·03	*trace*	10·20	5·10= 99·56
B.	22·40	56·40	*trace*	0·44	*trace*	*trace*	*trace*	21·13=100·37
C.	23·53	53·00	0·88	1·76	——	——	——	20·05= 99·22

Excluding the magnesia and reducing to a per-centage, B and C become

	$\dddot{\mathrm{Si}}$	$\bar{\dddot{\mathrm{Al}}}$	$\dot{\bar{\mathrm{H}}}$
B.	22·41	56·45	21·14
C.	24·36	54·88	20·76

The first (*A*) is near agalmatolite, whose formula is

$$\dot{\mathrm{K}}\,\dddot{\mathrm{Si}}+2\bar{\dddot{\mathrm{Al}}}^2\,\dddot{\mathrm{Si}}^3+3\dot{\bar{\mathrm{H}}}.$$

The other two are probably identical, and to these the name *Dillnite* is applied. Haidinger deduces the formula $\bar{\dddot{\mathrm{Al}}}^2\,\dddot{\mathrm{Si}}+4\dot{\bar{\mathrm{H}}}=$ Silica 24·97, alumina 55·56, water 19·47; and this he observes may be resolved into $\bar{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}+2\dot{\bar{\mathrm{H}}}$, the formula of nacrite and much kaolin, and $\bar{\dddot{\mathrm{Al}}}\,\dot{\bar{\mathrm{H}}}^2$, a hydrated alumina. [The formula $\bar{\dddot{\mathrm{Al}}}^2\,\dddot{\mathrm{Si}}+4\tfrac{1}{2}\dot{\bar{\mathrm{H}}}$ is still nearer C, giving silica 24·39, alumina 54·23, water 21·38.]

The diaspore of this locality has the specific gravity 3·340.

6. **Brongniardite**, (M. A. Damour, Ann. des Mines, [4], xvi, 227.)—Brongniardite is an ore of antimony, lead and silver, from the mines of Mexico, whence it was brought by M. de Castelnau. The specimen was a compact mass weighing about 15½ pounds, and having one surface sprinkled with pyrites. The following are its characters:—Massive, without cleavage. Lustre metallic, resembling that of polybasite or bournonite. Streak-powder grayish-black. Hardness above that of calcite, but scratched by a point of iron. Specific gravity at 18° C., 5·950.

B.B. on charcoal, decrepitates, fuses easily at a temperature below red heat, giving off an odor of sulphur and white vapors. After roasting, it yields a globule of silver, surrounded with a yellow areola of oxyd of lead. In a closed tube, decrepitates, fuses and affords a feeble sublimate of a reddish orange color, surmounted by a white sublimate. In an open tube decrepitates, fuses, and affords an odor of sulphur, and a white sublimate of peroxyd of antimony covers the walls of the tube. Rapidly attacked by concentric nitric acid, disengaging nitrous vapors and depositing sulphur, oxyd of antimony and sulphate of lead. With dilute acid there is a slow action yielding vapors of sulphuretted hydrogen; the silver and lead are partially dissolved, and there is a gray deposit in small needles of sulphuret and oxyd of antimony retaining a notable proportion of lead and silver. Attacked also by chlorohydric acid, and when pulverized by a boiling lye of caustic potash. Composition:—

	S	Sb	Ag	Pb	Cu	Fe	Zn
1.	19·38	29·95	25·03	24·74	0·54	0·30	0·40 = 100·34
2.	19·21	29·60	24·46	25·05	0·61	0·26	0·32 = 99·51
3.	19·14	29·75	24·81	24·94	0·70	0·22	0·37 = 99·93

The result gives the formula $Pb\,S + Ag\,S + Sb\,S^3$ [equivalent to $2(Pb, Ag)S + Sb\,S^3$,] = Sulphur 19·08, antimony 30·66, silver 25·65, lead 24·61 = 100.

M. Damour observes that the composition approaches most nearly that of the Schilfglaserz (Freislebenite), the mean of two analyses of which by Wöhler, is, S 18·74, Sb 27·38, Ag 22·93, Pb 30·27 = 99·32.

[The formula is identical in general character with that of feather ore (heteromorphite of Rammelsberg), it differing only in having half the lead replaced by silver. Wöhler's formula for the Freislebenite corresponds to $7(Pb, Ag)S + 3Sb\,S^3$ or $2\frac{1}{3}(Pb, Ag)S + Sb\,S^3$, the silver and lead being in the proportions of 3 to 4.*]

II. Described Species.

Dolomite from the Muschelkalk near Saarbrücken, (R. Wildenstein, J. für prakt. Chem., xlix, 154, 1850.)—This dolomite is crystalline granular, and yellowish gray in color. G. = 2·753. Composition according to Wildenstein:—

$\ddot{C}$ 46·30 $\dot{C}a$ 30·50 $\dot{M}g$ 20·13 $\dot{F}e$ 1·17 $\dot{K}$ trace, Clay and sand 1·88 = 99·98

or $\dot{C}a\,\ddot{C}$ 54·47, $\dot{M}g\,\ddot{C}$ 41·62, $\dot{F}e\,\ddot{C}$ 1·88, $\dot{K}$ trace, Clay and sand 1·88 = 99·85

Dolomite from the zinc mines of Altenberg near Aix la Chapelle, (K. Monheim, cited by J. f. pr. Chem., xlix, 318, from Verhandl. des nat. Vereines der preuss. Rheinlande, v., 41.)—Composition:—

$\dot{C}a\,\ddot{C}$ 54·31, $\dot{M}g\,\ddot{C}$ 43·26, $\dot{Z}n\,\ddot{C}$ 1·38, $\dot{F}e\,\ddot{C}$ 0·99, $\dot{M}n\,\ddot{C}$ 0·56, $\dddot{S}i$ 0·48 = 100·98,

corresponding to equal equivalents of carbonate of lime and carbonate of the other bases.

Green Spathic Iron from near the zinc mines of Altenberg, (K. Monheim, ibid, xlix, 318, from the same.)—The crystals have the specific gravity 3·60. Composition according to Monheim:—

$\dot{F}e\,\ddot{C}$ 64·04, $\dot{M}n\,\ddot{C}$ 16·56 $\dot{C}a\,\ddot{C}$ 20·22 $\dddot{S}i$ 1·10 = 101·92,

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* $9(Pb, Ag)S + 4Sb\,S^3$ or $2\frac{1}{4}(Pb, Ag)S + Sb\,S^3$ is even nearer the analysis of freislebenite, it giving,
Sulphur 18·65, antimony 28·65, silver 23·18, lead 29·57 = 100.—D.

This corresponds to $8\dot{\mathrm{Fe}}\ddot{\mathrm{C}}+2\dot{\mathrm{Mn}}\ddot{\mathrm{C}}+3\dot{\mathrm{Ca}}\ddot{\mathrm{C}}$. The mineral resembles the kapnite, a calamine containing over 15 per cent. of carbonate of iron (zinkeisenspath, of the Germans).

Electric Calamine from Altenberg, and from Retzbanya, Hungary.—Analyses by K. Monheim, (ibid, xlix, 319, from the same.)

	$\dddot{\mathrm{Si}}$	$\dot{\mathrm{Zn}}$	$\dddot{\overline{\mathrm{Fe}}}$	$\ddot{\mathrm{C}}$	$\dot{\overline{\mathrm{H}}}$
1. Altenberg, milky cryst.	24·31	65·74	0·43	0·31	7·51= 98·30
2. " limpid "	25·40	67·05	—	0·31	7·47=100·23
3. Retzbanya,	25·34	67·02	0·68	0·35	7·58=100·97

The results sustain the formula deduced by Berzelius, $2\dot{\mathrm{Zn}}^3\dddot{\mathrm{Si}}+3\dot{\overline{\mathrm{H}}}$. Specific gravity of the Altenberg mineral, 3·43, 3·45, 3·47, 3·49.

Manganesian Calamine.—Analyses by K. Monheim, (ibid, xlix, 382, from the same); 1, from Herrenberge near Riom, in pale green rhombohedrons; G.=4·03. 2, ibid, dull green, G.=2·98. 3, from Altenberg, G.=4·20.

	$\dot{\mathrm{Zn}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Mn}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Fe}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Mg}}\ddot{\mathrm{C}}$	$\dot{\mathrm{Ca}}\ddot{\mathrm{C}}$		
1.	85·78	7·62	2·24	4·44	0·98,	$\dddot{\mathrm{Si}}$ 0·09,	$\dot{\overline{\mathrm{H}}}$ *trace*=101·15
2.	74·42	14·98	3·20	3·38	1·68,	$\dddot{\mathrm{Si}}$ 0·20,	$\dot{\overline{\mathrm{H}}}$ 0·56 = 98·12
3.	84·92	6·80	1·58	2·84	1·58,	Electric calamine, 1·85=	99·57

Nontronite from Andreasberg.—Composition according to Mehner, (J. f. pr. Ch., xlix, 382, from Trommsdorff's J., xii, 27, 1826):

$\dddot{\mathrm{Si}}$	$\dddot{\overline{\mathrm{Fe}}}$	$\dddot{\overline{\mathrm{Al}}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Fe}}$	$\dot{\overline{\mathrm{H}}}$	
40·495	33·705	1·095	1·112	2·259	21·816=100·482.	G.=2·337

Pyrophyllite from Westanå, (N. J. Berlin, Pogg., lxxviii, 414.)—This pyrophyllite occurs in a quartzose gangue along with micaceous iron ore. G.=2·78—2·79. Analyses by Berlin:—

	$\dddot{\mathrm{Si}}$	$\dddot{\overline{\mathrm{Al}}}$	$\dddot{\overline{\mathrm{Fe}}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Mn}}$	$\dot{\overline{\mathrm{H}}}$
1.	67·77	25·17	0·82	0·66	0·26	0·50	5·82=101·00
2.	65·61	26·09	0·70	0·69	0·09	0·09	7·08=100·35
Oxygen,	34·09	12·42					6·29

In three other trials, the water came out 5·62, 5·77, 7·29. Berlin deduces the formula $\dddot{\overline{\mathrm{Al}}}^{2}\dddot{\mathrm{Si}}^{5}+2\dot{\overline{\mathrm{H}}}$=Silica 65·66, alumina 29·22, water 5·12. The result is very near Rammelsberg's, who suggested the same formula, and also as equally probable, $\dddot{\overline{\mathrm{Al}}}\dddot{\mathrm{Si}}^{3}+\dot{\overline{\mathrm{H}}}$= Silica 69 65, alumina 25·73, water 4 62. The composition, as stated by Berlin, is the same with that of an agalmatolite analyzed by Walmstedt; and Rammelsberg remarks upon its approximation to cimolite.

Stilbite of Gustafsberg, Sweden, and Barbro Mine, Norway, (ibid, 415). Analyses by Sjögren:

$\dddot{\mathrm{Si}}$	$\dddot{\overline{\mathrm{Al}}}$	$\dddot{\overline{\mathrm{Fe}}}$	$\dot{\mathrm{Ca}}$	$\dot{\overline{\mathrm{H}}}$
57·41	16·14	0·25	8·75	16·60 = 99·15
58·41	16·56	—	7·89	16·53, $\dot{\mathrm{Mg}}$, $\dot{\mathrm{Mn}}$, alkalies, 0·54 = 99·93

The mineral was dried in powder at 100 C. over sulphuric acid; and in this way, he found the water to correspond with the usual formula, instead of 18 to 19 p. c., as in many other analyses.

Sodalite from the Island Lamö near Brevig in Norway, (Pogg. Ann., lxxviii, 413.) This lavender blue mineral has been mistaken for glaucolite. It occurs in nodular masses in elæolite, and sometimes has a crust of the latter mineral. Composition according to von Borc:—

$\dddot{\mathrm{Si}}$	$\bar{\mathrm{Al}}$	$\dot{\mathrm{Na}}$	$\dot{\mathrm{K}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$
38·86	30·82	22·03	0·51	1·21	0·44, with *trace* of Sn, Mn, $\bar{\mathrm{W}}$, $\bar{\mathrm{Mo}}$, and chlorine undetermined =93·87.

A Red Zeolite from near Upsala, Sweden, (N. J. Berlin, Pogg., lxxviii, 415.)—The red zeolite of Upsala resembles that of Ædelfors. The following are analyses; 1, of the Upsala mineral by Sjögren; 2, of that of Ædelfors by Retzius; 3, the same by Hisinger; 4, a similar mineral from Fahlun by Hisinger; and 5, another from Märtenberg by the same.

	$\dddot{\mathrm{Si}}$	$\bar{\mathrm{Al}}$	$\bar{\mathrm{Fe}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{H}}$
1.	51·61	19·06	2·96	12·53	14·02=100·18
2.	60·28	15·42	4·16	8·18	11·07= 99·11
3.	53·76	18·47	4·02	10·90	11·23= 98·38
4.	60·00	15·6	1·8	8·0	11·6 = 97·0
5.	53·37	16·50	2·36	13·00	10·67= 95·90

Berlin deduces for the Upsala mineral, the formula

$$\dot{\mathrm{Ca}}^3\dddot{\mathrm{Si}}^2+3\bar{\mathrm{Al}}\dddot{\mathrm{Si}}^2+12\dot{\mathrm{H}}$$

=Silica 51·53, alumina 21·49, lime 11·92, water 15·06=100. This is Gerhardt's formula for laumonite.

Berlin suggests that the other minerals may be the same species and that the difference is due to an excess of silica from mixed quartz.

Hyposclerite, (C. Rammelsberg, Pogg., lxxix, 305.)—This mineral from Arendal was named and described by Breithaupt and analyzed by Hermann; the latter obtained the oxygen ratio 1 : 2 : 6 and formula $\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}^2+2\bar{\mathrm{Al}}\dddot{\mathrm{Si}}^2$. Rammelsberg has arrived at a very different result, and for comparison Hermann's analysis is also inserted in this place. G.=2·61, Breithaupt; 2·66, Hermann; 2·63—2·66, Rammelsberg.

	$\dddot{\mathrm{Si}}$	$\bar{\mathrm{Al}}$	$\bar{\mathrm{Fe}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Na}}$	$\dot{\mathrm{K}}$	
1. Herm.,	56·43	21·70	0·75	4·83	3·39	0·39	5·79	2·65,	$\dot{\mathrm{Ce}}$ & $\dot{\mathrm{La}}$ 2, ign.* 1·87=99·80
2. Ramm.,	67·62	16·59	2·30	0·85	1·46	——	10·24	0·51,	ign. 0·69=100·26.

Rammelsberg thus shows that the species is nothing but albite, giving the ratio 1 : 3 : 12, or more exactly 1·25 : 3 : 12·5. Allowing for a small admixture with pyroxene the slight discrepancy that exists is removed.

Castor and Petalite identical, (G. Rose, Pogg., lxxix, 162.)—G. Rose in this memoir shows that castor and petalite are identical in cleavage, hardness and physical characters, corresponding to their close approximation in chemical composition. From a specimen in the Berlin Royal Museum he obtained the angle 129°, near that given by Breithaupt; but one of the planes (P) was *not* a cleavage plane. The other plane (M) was transversely striated and a second cleavage was found parallel to the striations, which gave with M the angle 141° 32′–141° 35′. This angle is the same observed in petalite, and this was confirmed from specimens by Prof. Rose, who obtained 141° 35 to 142°. Petalite affords in the same zone on the other side of M still a third cleavage (imperfect, however,) which according to Breithaupt forms with M the angle 117°; but this was not detected with certainty in the mineral castor; the largest specimen in hand was but five lines long. The following results show the similarity in composition.

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* The expression *ign.* in this and other places, stands for "loss by ignition."

	$\dddot{\mathrm{Si}}$	$\dddot{\overline{\mathrm{Al}}}$	$\dot{\mathrm{Li}}$	$\dot{\mathrm{Na}}$
1. *Petalite,*	77·067	18·000	2·660	2·273=100. Hagen.
2. *Castor,*	78·012	18·856	$\dot{\mathrm{Li}}$ and trace of $\dot{\mathrm{K}}$,$\dot{\mathrm{Na}}$ 2·760, $\dddot{\overline{\mathrm{Fe}}}$ 0·613=100·241, Plattner.	

The characters with the blowpipe and acids are also similar.

Manganesian Idocrase, (M. Websky, Pogg., lxxix, 166.)—This idocrase is associated with a mangan-epidote, heteroclin and a fusible mica in quartz, at St. Marcel in Piedmont. The crystals are like those of ordinary idocrase. Color sulphur to honey yellow; streak white. Glass of borax with a small portion of the mineral becomes readily in the oxydation flame of an amethystine color; and in the reduction flame with tin there is a weak iron reaction.

Thulite from the Iron Mine Klodeberg near Arendal, Norway, (N. J. Berlin, Pogg., lxxviii, 414.)—The thulite of this locality resembles rhodonite; it occurs massive, with a splintery fracture and fine rose-red color. G.=3·34. Composition according to Berlin:—

$\dddot{\mathrm{Si}}$	$\dddot{\overline{\mathrm{Al}}}$	$\dddot{\overline{\mathrm{Fe}}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\overline{\mathrm{Mn}}}$	$\dddot{\mathrm{V}}$	ign.	
40·28	31·84	1·54	21·42	0·66	0·95	0·22	1·32	=98·23;

the alkali was undetermined. The constitution is that of epidote.

Allanite from Krux near Schmiedefeld in Thüringer-Wald, (H. Credner, of Gotha, Pogg., lxxix, 144.)—The allanite occurs in a coarse granite, and also along with crystals of specular iron, overlaid by calcite and fluor spar, in a bed of magnetic iron ore. It is either massive or crystallized. H.=5½ to 6. G.=3·790, mean of four determinations. Not magnetic. Color jet black, with a faint greenish tinge. Streak and powder greenish-gray, inclining somewhat to brownish yellow. B.B. on charcoal fuses with little intumescence to a black shining globule; with borax, and more distinctly still with salt of phosphorus, gives in either flame a brownish yellow glass which is colorless when cold, and with the latter reagent leaves a silica skeleton. In a matrass yields some water, without changing color. Not decomposed by muriatic acid. Composition according to Credner:—

	$\dddot{\text{Si}}$	$\dddot{\bar{\text{A}}}\text{l}$	$\dot{\bar{\text{L}}}\text{a}$	$\dot{\text{C}}\text{e}$	$\dot{\text{Y}}$	$\dot{\text{F}}\text{e}$	$\dot{\text{M}}\text{n}$	$\dot{\text{C}}\text{a}$	$\dot{\text{M}}\text{g}$	$\dot{\bar{\text{H}}}$	
1.	36·82	16·94	13·32		17·11		0·56	14·84	0·86	0·28	=100·73
2.	37·55	15·99	9·30	3·19	0·56	16·88	0·23	13·60	0·22	1·80	= 99·27

The proportion of silica is larger than in other allanites, and that of oxyds of cerium and lanthanum less. Credner observes that Scheerer obtained the oxygen ratio for protoxyds, peroxyds and silica 2 : 3 : 5, but that his result agrees more nearly with 2 : 3 : 6. [Scheerer's formula for his allanite was $3\dot{\text{R}}^3\dddot{\text{Si}}+2\dddot{\bar{\text{R}}}\dddot{\text{Si}}$, corresponding to the ratio 3 : 2 : 5. Rammelsberg has since examined the orthite of Hitteroe and obtained the ratio 1 : 1 : 2, by special investigation with respect to the state of oxydation of the bases. If so much of the iron in the first of the preceding analyses be considered peroxyd as will give the ratio 1 : 2 between the oxygen of the alumina and silica, the other bases in the analysis being taken as protoxyd, make very nearly the amount necessary to afford the ratio 1 : 1 : 2; calculation giving for the oxygen 9·30 : 9·56 : 19·13.]

On the Mineralogical and Chemical composition of some Rocks; by M. Delesse, (Ann. des Mines, [4] xvi, 233, 323.)—1. *Quartziferous porphyry;* a, *a variety from Montreuillon, district of Château-Chinon*, containing quartz in small dodecahedral crystals, and lamellar macles of white orthoclase, a little red andesite and a green mica, disseminated through a whitish or greenish white feldspathic paste.—b, *a variety from near Saulieu* (*Cote-d'Or*,) containing grains of hyaline quartz, some orthoclase in reddish lamellar crystals, in a brownish red feldspathic base.

	$\dddot{\text{Si}}$	$\dddot{\bar{\text{A}}}\text{l}$	$\dddot{\bar{\text{F}}}\text{e}$	$\dddot{\bar{\text{M}}}\text{n}$	$\dot{\text{C}}\text{a}$	$\dot{\text{K}}$, $\dot{\text{N}}\text{a}$, $\dot{\text{M}}\text{g}$,	ign.	
a.	71·7	15·0	2·9	——	0·4	(diff.) 8·8	1·2	=100
b.	77·5	12·9	2·5	*traces*	0·4	" 6·7	—	=100

2. *Feldspar of a Euphotide;* a, *from Mount Genèvre;* b, *from Odern in the Vosges.*—The feldspar in each case is in lamellar macled crystals of the triclinic system, and has a white or greenish color.

	$\dddot{\text{Si}}$	$\dddot{\bar{\text{A}}}\text{l}$	$\dddot{\bar{\text{M}}}\text{n}$	$\dot{\text{F}}\text{e}$	$\dot{\text{C}}\text{a}$	$\dot{\text{M}}\text{g}$	$\dot{\text{N}}\text{a}$	$\dot{\text{K}}$	ign.	
a. (mean)	49·73	29·65	*trace*	0·85	11·18	0·56	4·04	0·24	3·75	=100
b. "	55·28	24·24		$\dddot{\bar{\text{F}}}\text{e}$ 1·11	6·86	1·48	4·83	3·03	3·05	= 99·83

The specimens were not wholly free from talc and minute veins of serpentine matters. The latter had a neater cleavage than is usual with the feldspar of euphotide, yet was impure also with some carbonate, probably a carbonate of iron, lime and magnesia. Delesse observes that a large proportion of silica and alkalies with less of alumina and lime explains the neater cleavage. He deduces for the $\dot{\text{R}}$, $\dddot{\bar{\text{R}}}$ and $\dddot{\text{Si}}$ of No. *b*, the oxygen ratio 1 : 3 : 7. It is evident that the feldspar of euphotide differs in species, and is not always labradorite as Boulanger supposed; it sometimes approaches labradorite, sometimes anorthite, and sometimes other varieties of feldspar.

3. *Diallage of the Euphotide of Odern.*—The diallage is in olive green crystalline lamellæ. It fuses before the blowpipe with very great difficulty, much greater than the feldspar associated with it. It afforded

$\dddot{\mathrm{Si}}$	$\ddot{\mathrm{\bar{A}l}}$	$\ddot{\mathrm{\bar{C}r}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	ign.
49·30	5·50	0·30	9·43	0·51	15·43	17·61	0·85=98·93

Delesse observes that it approaches hornblende, especially that from Nordmark analyzed by Bonsdorff. The chromic acid he believes to be chemically combined in the mineral. He deduces the formula $\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}^2$, which is the formula of the species pyroxene. The oxygen for the protoxyds, peroxyds and silica equals 13·51 : 2·66 : 25·61; and supposing the alumina to replace the silica, the ratio 1 : 2, characteristic of pyroxene, is given. This ratio is more exact when silica and alumina replace one another in the ratio of $3\ddot{\mathrm{\bar{A}l}} : 2\dddot{\mathrm{Si}}$.

4. *Talc of the Odern Euphotide.*—This talc is in imperfectly radiated translucent lamellæ, often more than a centimetre in length, and constitutes compact masses which cut like a soapstone. Composition:—

$\dddot{\mathrm{Si}}$	$\ddot{\mathrm{\bar{A}l}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$ (diff.)	ign.
59·61	0·81	3·95	0·56	2·88	28·41	3·78=100

This result shows, Delesse observes, that it is near that from Little St. Bernard, analyzed by Berthier, and may be represented by the pyroxene formula $\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}^2$.

[The oxygen of the protoxyds and silica equals 12·99 : 30·97 (=1 : 2·38) with 0·38 for that of the alumina. The ratio corresponding is 3 : 7, (the alumina being excluded,) which is equivalent to $\dot{\mathrm{Mg}}^9\,\dddot{\mathrm{Si}}^7$. The ratio 4 : 9 (=1 : 2·25) which differs but little from the result, affords the formula $\dot{\mathrm{Mg}}^4\,\dddot{\mathrm{Si}}^3$, which has been found for other varieties of talc.]

5. *Serpentine of the Euphotide of Odern.*—The serpentine is sometimes in veins as if subsequently filled into fissures, and sometimes in nodules within feldspar, or so graduates into feldspar that it seems to have been formed at the expense of this mineral or of the euphotide as a whole, by a species of metamorphism.

6. *Hornblende of the Diorite of Pont Jean*, valley of the Moselle, near St. Maurice in the Vosges.—This hornblende is fibrous and of a fine green color and forms lamellar masses. G.=3·059. Composition:—

$\dddot{\mathrm{Si}}$	$\ddot{\mathrm{\bar{A}l}}$	$\ddot{\mathrm{\bar{C}r}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$ (diff.)	$\dot{\mathrm{Na}}$	$\dot{\mathrm{K}}$	ign.
50·04	8·95	0·24	9·59	0·20	11·48	18·02	0·81	0·08	0·59=100

The soda is attributed to feldspar which was detected in the mineral with a lens.

7. *Feldspar of the Diorite of Pont Jean.*—The hornblende is associated with a greenish feldspathic paste containing striated crystalline tables of a triclinic feldspar, which sometimes have a radiated arrangement. B.B. more fusible than the hornblende, as

usual with the feldspar of diorites; attacked by sulphuric acid. Composition:—

$\dddot{\mathrm{Si}}$	$\dddot{\mathrm{\bar{A}l}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{Na}}$	$\dot{\mathrm{K}}$	ign.
53·05	28·66	0·90	*trace*	6·37	1·51	4·12	2·80	2·40=99·81

It is a variety of labradorite. Delesse concludes that the radiated structure is found more especially in feldspars containing the smaller proportions of silica.

8. *Aphanite of Saint-Bresson* (*Haute-Saône.*)—The color is deep green, verging towards grayish black. It is very tough and compact. It fuses easily in a glass furnace and affords an obsidian about as hard as that of feldspar. G.=2·968. Composition:—

$\dddot{\mathrm{Si}}$	$\dddot{\mathrm{\bar{A}l}}$, $\dddot{\mathrm{\bar{F}e}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$ (diff.)	$\dot{\mathrm{Na}}$	$\dot{\mathrm{K}}$	ign.
46·83	30·33	*trace*	9·55	6·86	3·57	0·87	1·99=100

The small proportion of silica is worthy of note. The main ingredient is a feldspathic paste, which it is difficult to assign to any species.

9. *Andesite of the Diorite of Faymont.*—Lustre a little greasy and with the other characters of andesite. Composition:—

$\dddot{\mathrm{Si}}$	$\dddot{\mathrm{\bar{A}l}}$	$\dddot{\mathrm{\bar{F}e}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Na}}$, $\dot{\mathrm{K}}$, (diff.)	ign.
59·38	25·57	*trace*	6·50	7·30	1·25=100

The crystals are often penetrated or enclosed by quartz, showing that they were formed amid an excess of silica.

10. *Hornblende of the Diorite of Faymont.*—Occurs in black lustrous laminæ and in crystals. Composition:—

$\dddot{\mathrm{Si}}$	$\dddot{\mathrm{\bar{A}l}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$ (diff.)	Alkalies	ign.
41·99	11·86	22·22	9·55	12·59	1·32	0·47=100

Associated with the hornblende, there is sometimes black mica, pyrites, a little magnetic iron, and sphene.

11. *Feldspar of the porphyry of Schirmeck.*—This feldspar is in tables, oblong and striated, and pertains to the triclinic system. It is slightly greenish and a little pearly in lustre. G.=2·686. Composition:—

$\dddot{\mathrm{Si}}$	$\dddot{\mathrm{\bar{A}l}}$, $\dddot{\mathrm{\bar{F}e}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Na}}$, $\dot{\mathrm{K}}$, $\dot{\mathrm{Mg}}$ (diff.)	ign.
65·74	18·49	4·17	10·60	1·00=100

Delesse considers it an oligoclase, judging from the proportion of silica and amount of lime.*

Wolfram.—Analyses by Robert Schneider of Halle, (J. f. pr. Chem., xlix, 322.)

	$\dddot{\mathrm{W}}$	$\dot{\mathrm{Fe}}$	$\dot{\mathrm{Mn}}$	$\dot{\mathrm{Ca}}$	$\dot{\mathrm{Mg}}$	
1. Zinnwald,	76·01	9·81	13·90	1·19	——	=100·91=$2\dot{\mathrm{Fe}}\dddot{\mathrm{W}}+3\dot{\mathrm{Mn}}\dddot{\mathrm{W}}$.
2. Hartz, Mine Glasebach,	76·04	19·61	4·98	0·28	*trace*	=100·92=$4\dot{\mathrm{Fe}}\dddot{\mathrm{W}}+\dot{\mathrm{Mn}}\dddot{\mathrm{W}}$.
3. Hartz, Mine Pfaffenberg,	76·21	18·54	5·23	0·40	0·36	=100·74=$4\dot{\mathrm{Fe}}\dddot{\mathrm{W}}+\dot{\mathrm{Mn}}\dddot{\mathrm{W}}$.
4. Hartz, Mine Meiseberg,	76·25	20·27	3·96	0·28	0·15	=100·91=$5\dot{\mathrm{Fe}}\dddot{\mathrm{W}}+\dot{\mathrm{Mn}}\dddot{\mathrm{W}}$.

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* M. Delesse states in a note that geologists wishing collections of the rocks of the Vosges described in his memoirs, can obtain them by addressing M. Mareine, conducteur des ponts-et-chaussées, à Remiremont (Vosges.) He will give full labels with the specimens, and charges the moderate sum of 30 francs for 100 specimens.

This last result is the mean of three analyses; the per-centage relation for the formula is, $\dddot{\text{W}}$ 76·36, $\dot{\text{Fe}}$ 19·74, $\dot{\text{Mn}}$ 3·90 = 100.

Schneider concludes from his investigations that the true view of the composition of Wolfram is expressed by the genera formula $\dot{\text{R}}\,\dddot{\text{W}}$, making wolframic or tungstic acid to contain three atoms of oxygen.

Native Copper containing Silver from Chili, (M. F. Field, Quart. J. Chem. Soc., No. ix, iii, 29.)—A native copper from a mine about twenty leagues east of Coquimbo and six from the Cordillera of the Andes, afforded Mr. Field for one specimen, Copper 98·91, silver 1·09 = 100; for a second, of a whitish color, Copper 92·4, silver 7·6 = 100.

Native Gold.—Analyses by A. Levol, (Ann. Ch. Phys., [3] xxvii, 310.)

	Gold.	Silver.	Copper.	Ratio of Au to Ag.
1. Senegal, grains,	84·50	15·30	0·20	6 : 1=Au 84·6
2. " large scales,	86·80	11·30	0·90	8 : 1= 88·0
3. N. America, grains,	91·00	8·70	0·30	12 : 1= 91·6
4. California, a piece,	92·70	6·90	0·40	14 : 1= 92·7
5. Senegal, irregular grains,	94·00	5·85	Plat. 0·15	18 : 1= 94·2
6. A piece, loc. not given.	98·30	1·70		58 : 1= 98·1

On the Meteoric Iron of Zacatecas; by Dr. C. Bergemann of Bonn., (Pogg. Ann., lxxviii, 406.)—The Zacatecas meteorite, which has been described by Sonneschmidt, Humboldt, and others, has been recently analyzed by Dr. Bergemann. The mass weighs over 20 cwt. It has a light steel gray color within, a hackley fracture, and the crystalline figures are small and irregular. Specific gravity according to Bergemann 7·4891, at 9° C., which agrees with the determinations by Burkart and Rumler. Analysis gave for its composition:

Fe	Ni	Co	Cu	Mg	Mn	C	S	C & a little Fe	Fe, Ni, P	$\dot{\text{Fe}}\ddot{\text{Cr}}$
85·094	9·895	0·668	0·630	0·187	*trace*	0·164	0·845	0·334	1·649	1·482

Dr. Bergemann thence deduces for its actual constitution—

Nickeliferous iron, ...	93·77
Magnetic pyrites, ...	2·27
Chromic iron, ...	1·48
Phosphuret of nickel and iron, . . .	1·65
Carbon, ...	0·49
	99·66

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Preparation of Metacetonic Acid;* by Dr. F. Keller, (Chem. Gazette, May 1st, from Liebig's Annalen, Feb., 1850.)—A quantity of wheat paste is mixed with ten parts of water at 122°–140° F.; one fourth its weight of scraps of leather is then added with a quantity of chalk and the whole left in a warm place to ferment. At the end of a few days in summer, the process is complete and a light spongy mass subsides. The lime salt is converted into a soda salt, and the acid separated by sulphuric acid, is found to be a mixture of metacetonic with acetic acid. These are separated by saturating a portion with carbonate of soda, adding the remainder and distilling off the metacetonic acid, which by this process is readily obtained in large quantities. T. S. Hunt.

2. *On the Amid Compounds of Tungsten;* by Prof. Wöhler, (Chem. Gazette, May 1st, from Göttingen Nachrichten, 1850.)—When dry ammonia is passed over protochlorid of tungsten, a reaction takes place at first spontaneous which is completed by the aid of a gentle heat, sal-ammoniac and hydrogen gas being evolved. The product is a black partially fused mass, which evolves ammonia when heated in the open air and finally burns, yielding yellow tungstic acid. Heated to whiteness in a charcoal lined crucible, it leaves metallic tungsten, and a similar result is obtained in a current of hydrogen gas at a low red heat, ammonia being disengaged. Fused with hydriodate of potash, a tungstate is formed with the evolution of hydrogen and ammonia. From the results of analysis, M. Wöhler concludes, that there are two very similar compounds, a nitruret and amidid of tungsten, the second being a product of the decomposition of the first by the action of hydrogen, and that the two are generally obtained in a state of admixture. He represents the one as $2WN+WNH_2$ and the other as W_2N+WNH_2.

The action of ammonia upon tungstic acid at a low red heat yields a substance resembling the latter in its properties, of which the composition is represented by $3WN+W_2NH_2+2WO_2$. Identical with or very similar to this is the product obtained by igniting out of contact of air a mixture of tungstate of potash with chlorid of ammonium, which was a long time since described by the author as the black oxyd of tungsten. It however evolves hydrogen and ammonia by the action of hydrate of potash, and even when heated alone. When heated to whiteness in a close vessel, it leaves metallic tungsten.

Wöhler finds, that contrary to the statement of Berzelius, tungstic acid is not reduced to the metallic state by the action of hydrogen; at a temperature above the melting point of silver an oxyd is obtained which is not farther changed. It is of a violet brown color, and under a magnifier appears crystalline with a metallic lustre.

[These different combinations of tungsten, nitrogen and hydrogen, with the addition in some cases of oxygen, will probably be found to correspond to different ammoniacal salts of the polymeric forms of tungstic acid as yet imperfectly known. The different amids of phosphoric acid already described by M. Gerhardt are analogous compounds.] T. S. H.

3. *On the Decomposition of Iodid of Potassium;* by Prof. SCHÖNBEIN, (Chem. Gazette, May 1st, 1850, from Pogg. Annal., lxxviii, p. 513.)—The anhydrous metallic acids, arsenic, molybdic, tungstic, antimonic and chromic, when triturated with iodid of potassium, separate iodine even in the cold, and abundantly by the aid of heat; artificial stannic acid as well as the native tin-stone effect a similar decomposition by heat. With bichromate of potash the whole of the iodine may be expelled, while neutral chromate of potash and oxyd of chromium remain behind; three parts of the bichromate suffice to decompose two of the iodid, the reaction being

$$5(KO,2Cr\,O_3)+3KI=8(KO\,Cr\,O_3)+Cr_2\,O_3+3I.$$

Anhydrous perchlorid of iron liberates iodine from the iodid of potassium at the ordinary temperature, and a highly concentrated solution of the perchlorid of iron, mixed with an equally concentrated solution of the iodid, precipitates a large portion of the iodine in a crystalline form; $Fe_2\,Cl_3+KI=2Fe\,Cl+K\,Cl+I$.

The persulphate and all the persalts of iron act in a similar manner, so that the peroxyd of iron may be used instead of the peroxyd of manganese to separate iodine from alkaline iodids.

The dry persalts of copper, even the carbonate, liberate iodine from the iodid on the application of heat.

The bromid of potassium in the dry way is affected by most of these reägents, but with less ease than the iodid. Bichromate of potash and persalts of iron are most efficient; the latter may also be employed in the moist way to obtain bromine by distillation.

The chlorids of K and Na are not decomposed by any of the above agents, even at a strong heat; but a partial decomposition is effected especially with bichromate of potash and the chlorids of Ba, Sn, Ca and Mg, attended with the evolution of chlorine and the formation of neutral chromates and oxyd of chromium. T. S. H.

4. *On Furfurol;* by A. CAHOURS, (Ann. de Chim. et de Phys., xxvi, 277).—The author has reëxamined this substance which he prepared by the action of sulphuric acid upon bran as recommended by Dr. Fownes;* by employing a little less sulphuric acid he obtained a much larger portion of the oil, 100 parts of bran yielding 2·75 parts of furfurol. The distillation of bran with water alone, does not yield any, nor can it be obtained from lignine, starch or gluten, even by the aid of sulphuric acid.

The analyses of M. Cahours confirm the exactness of the composition given by Fownes to furfurol. The specific gravity of its vapor is 3·342–3·346, corresponding for two volumes to the formula $C_5\,H_4\,O_2$, the equivalent which had already been adopted by Laurent and Gerhardt.

Chlorine and bromine give with furfurol only resinoid products; nitric acid, whether concentrated or diluted, acts energetically upon it, and gives as the final product oxalic acid. M. Cahours has also confirmed the results of Fownes as to furfuramid and furfurine. The action of sulphuretted hydrogen upon an alcoholic solution of furfuramid or of hydrosulphuret of ammonia on furfurol produces a sulphuretted compound *thiofurfurol*, $C_5H_4(OS)$. Seleniuretted hydrogen gives an analogous compound. By dry distillation thiofurfurol is transformed into a substance crystallizing in colorless needles, very soluble in alcohol and slightly soluble in boiling water. It contains $C_9H_8O_2$ and is formed from two equivalents of furfurol; $2C_5H_4(OS)=C_9H_8O_2+CS_2$. T. S. H.

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* This Journal, new series, vol. ii, p. 407.

5. *On the action of Chlorine upon Lactic Acid;* by G. Staedeler, (Ann. der Chem. und Pharm., lxix, 333.)—The author has recognized the production of *aldehyde* and *chloral* by the distillation of lactic acid with a mixture of sea-salt, peroxyd of manganese, and sulphuric acid. When the quantity of chlorine is small the aldehyde predominates. T. S. H.

6. *Preparation of Oxychlorid of Carbon;* by A. W. Hofmann, (Ann. der Chem. und Pharm., lxx, 129.)—A convenient and rapid mode of preparing this compound of oxyd of carbon and chlorine is to pass a stream of carbonic oxyd gas through perchlorid of antimony in ebullition; the salt is reduced to a protochlorid. This reaction may serve to detect oxyd of carbon in a gaseous mixture, for the odor of the oxychlorid is very characteristic. T. S. H.

7. *On the Preparation of pure oxyd of Cobalt;* by P. Louyet, (Comptes Rendes des Trav. de Chim., Oct., 1849.)—The ordinary process for purifying oxyd of cobalt from the oxyds of nickel and iron with which it is almost always associated, is that of M. Liebig, which consists in converting them into sulphates and exposing the dried salts to a red heat. By this means the sulphates of iron and nickel are decomposed with the escape of their acid, while the sulphate of cobalt is unchanged. The author has however found that when mixed with a large amount of sulphate of cobalt, a portion of the iron salt escapes decomposition even after a long continued red heat. He recommends for the purification of the product thus obtained the following process.

The calcined sulphate is dissolved in water, and a portion of gelatinous hydrated oxyd of cobalt is added, or what is the same thing, a quantity of carbonate of soda sufficient to precipitate in the form of carbonate a portion of the cobalt. The mixture is digested for some time at a boiling heat, until the violet color of the oxyd of cobalt is replaced by the dirty yellow of oxyd of iron, from the decomposition of the iron salt by the cobaltic oxyd. If the cobalt precipitate be slightly in excess, the salt of cobalt remaining in solution contains not the slightest trace of iron; the nickel of the impure oxyd is entirely removed by the previous process of calcination. T. S. H.

8. *On the action of heat upon the Caprylate of Lime;* by G. Guckelberger, (Ann. der Chem. und Pharm., lxix, 201.)—The dry distillation of this salt mixed with an excess of hydrate of lime yields an oily matter which after a little time becomes solid, and is purified by crystallizing in boiling alcohol. It is *caprylone*, an acetonid like that afforded by the lime salts of the homologous acids, and forms a

white crystalline mass resembling china wax. It is lighter than water, in which it is insoluble, tasteless and nearly inodorous; it fuses at 40° C., and boils at 178° C., distilling without alteration. Analysis gives for its formula $C_{15}H_{30}O$, and its formation is by the polymorphosis of two equivalents of caprylate; $2C_8H_{15}BaO_2 - CO_3Ba_2 = C_{15}H_{30}O$.

It is not affected by potash, nor by nitric acid in the cold; by heat the action of the latter is violent, yielding a yellow compound which forms detonating salts and is evidently a nitrized acid. T. S. H.

9. *On the determination of Nitrogen;* by **Noellner**, (Ann. der Chem. und Pharm., lxvi, 314.)—In the determination of nitrogen by igniting the substance with soda-lime after the process of Will and Varrentrapp, the author proposes to pass the ammoniacal vapors through a solution of tartaric acid in absolute alcohol. The bitartrate of ammonia which is thus formed is complely insoluble, and is deposited in a crystalline form. T. S. H.

10. *Examination of Castoreum;* by F. **Woehler**, (Ann. der Chem. und Pharm., lxvii, 360.)—The author had already suggested the existence of *phenol* in this substance, and has been able to verify it by distilling the castoreum with water, when a small portion of an oily liquid having all the reactions of phenol was obtained. The residue of this distillation yielded crystals of *benzoic acid* and *salicine*, and the mother liquid from the crystals of the benzoic acid gave with ferric salts the reactions of *salicylic acid.* T. S. H.

11. *On the Composition and Metamorphoses of Conine;* by J. **Blyth**, (Compt. Rend. des Trav. de Chem., Oct., 1849, from Ann. der Chem. und Pharm., lxx, 73.)—The recent analytical results of this chemist do not accord with those already obtained by M. Ortigosa. The difficulty of obtaining the alkaloid in a pure state is such that it is not easy to deduce a reliable formula except from the analyses of its saline combinations. From a careful comparison of the results, M. Gerhardt is led to retain the formula already adopted by him in his Précis (vol. ii, p. 66), $C_8 H_{15} N$, or in the ordinary notation, $C_{16} H_{15} N$; that of Mr. Blyth is $C_{17} H_{17} N$, and that of Ortigosa $C_{16} H_{16} N$, neither of which gives a number of equivalents of nitrogen and hydrogen divisible by 4. The results obtained by M. Ortigosa approach very closely to those calculated from M. Gerhardt's formula.

According to Mr. Blyth, the boiling point of conine is 168°–171° C.; but it is altered by heat so that the temperature rises during the distillation. Its density is ·878. It is volatile at ordinary temperatures, giving off a pungent odor which affects the eyes and produces white fumes with nitric, hydrochloric and acetic acids. In a dry state it does not affect test papers, but on the addition of a drop of water its reaction is strongly alkaline. Conine readily coagulates albumen, and precipitates the salts of Cu, Pb, Zn, Mn, Al and Fe, it precipitates also nitrate of silver but an excess of conine dissolves the precipitate; it dissolves the chlorid of silver as readily as ammonia. Most of the salts of conine are decomposed by evaporation, leaving gummy residues; many of these are crystallizable as the hydrochlorate, but very deliquescent.

Conine is a very alterable substance and resinifies by the action of the air; the ordinary product of its oxydation is *butyric acid*, which is obtained from it in various ways,—by boiling a solution of the chloroplatinate, by acting upon it with an excess of bromine and evaporating in the product *in vacuo*, by chromic and nitric acids, etc. According to M. Gerhardt the reaction will be as follows $C_8 H_{15} N + 2H_2O + O_2 = 2C_4 H_8 O_2 + N H_3$.

Mr. Blyth supposes a simultaneous formation of carbonic acid which his formula demands. T. S. H.

12. *On the Composition and Metamorphoses of Piperine;* by Th. Wertheim, (Comptes Rend. des Trav. de Chim., Oct., 1849, from Annal. der Chem. und Pharm., lxx, 58.)—The *chloro-platinate of piperine* is obtained by mixing concentrated alcoholic solutions of piperine and bichlorid of platinum, and having added an excess of concentrated hydrochloric acid, abandoning the mixture to spontaneous evaporation. It is obtained in very large fine crystals of an orange red color, which are very little soluble in water, but are apparently decomposed by a large portion, and are to be washed with strong alcohol. The composition of this salt deduced by the author from his analyses is $(C_{70} H_{37} N_2 O_{10}, ClH, Pt Cl_2)$, and he concludes that crystallized piperine contains 2 eq of Aq, and is $C_{70} H_{37} N_2 O_{10} + 2H O$.

When piperine is mixed with three or four parts of soda-lime and exposed to a temperature of 150°–160° C., there passes over a large amount of a colorless oily alkaloid, without a trace of ammonia, which is found to be identical with the *picoline* of Mr. Anderson. The residue is brown and contains a yellowish azotized resin having acid properties. If the mixture of piperine and soda-lime is heated to 200° C., ammonia is disengaged with the picoline, and the residue contains an uncrystallizable acid which is not nitrogenous.

The formula above proposed does not correspond with the law of divisibility, and M. Gerhardt proposes in its place the following formula deduced from the analyses of M. Laurent and his own, and closely according with the results obtained for the chloro-platinate by the author. $C_{35} H_{36} N_2 O_5 + Aq$, or in the German notation, $C_{70} H_{36} N_2 O_{10} + 2H O$.

He remarks that the decomposition evolving picoline and ammonia, shows piperine to be a diamid, analogous to the *carbanilamid* of M. Chancel,* in which the two equivalents of alkaloid will be represented by picoline and ammonia coupled with a non-azotized (bibasic) acid; the azotized acid resinous body described, will be the monobasic amid-acid of the former. These two acid bodies have been analyzed by M. Wertheim, but not being crystallizable we have not yet data for determining satisfactorily their composition. T. S. H.

13. *On a New Gunpowder;* by M. Augendre, (Comptes Rendus, in Chemical Gaz., May, 1850.)—The proportions giving least residue with maximum effect are—

Powdered crystallized yellow prussiate of potash, . .	1 pt.
" white sugar, ...	1 "
" chlorate of potash, ...	2 "

The ingredients separately powdered are carefully mixed, small quantities may be rubbed together in a mortar; for large quantities 2 or 3 per cent. of water must be added and the mixture made in a bronze mortar with a wooden pestle, and it may then be granulated and dried.

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* This Journal, March, 1850, p. 275.

This compound differs from ordinary gunpowder in being explosive even in the form of fine powder, no granulation is therefore needed. Other advantages claimed for it are its easy formation, the ingredients previously powdered may be mixed only when wanted—the want of action of air on the separate materials, while charcoal for gunpowder is injured by exposure; and lastly, the greater force.

On the other hand are its erosive effect on iron barrels, for which bronze must be substituted, and its dangerous inflammability.

[This compound having already obtained a newspaper notoriety has probably been very generally tried. The cost of materials and the difficulty of keeping it will be a bar to very extensive use. In our own trials, it was found to become somewhat moist, and the original pulverization was found difficult in the case of the sugar and prussiate of potash.

It is dangerous to introduce gunpowder, charcoal or sulphur; the smallest quantity caused, in the hands of the discoverer, a tremendous explosion.] G. C. SCHAEFFER.

14. *Purification and properties of Chloroform;* by Prof. WM. GREGORY, M.D., (Med. Jour. Sciences, in Chem. Gaz., May, 1850.)—Prof. G. in general confirms the results of Soubeiran and Mialhé.* Still even from the hands of the best manufacturers, chloroform has until recently been found contaminated by chlorinated oils mentioned in our former notice. Prof. G. considers the disagreeable effects of chloroform as entirely due to these oils. It is therefore a matter of some consequence to have delicate tests for the purity of this important substance.

Pure and colorless sulphuric acid of 1·84 at least, on agitation is colored yellow or brown, as the oil is more or less impure. Perfectly pure chloroform does not color the acid.

Pure chloroform when poured upon the hand or a handkerchief, rapidly evaporates, while the less volatile oils remain and are recognized by their color, which is quite persistent. Dr. Simpson mentioned to the author that while using a chloroform, which had so constantly produced unpleasant effects that he threw it away, the handkerchiefs became quite offensive from the smell left upon them which remained after washing. Another test is the specific gravity which for the perfectly pure article is 1·500.

Mr. Kemp, the author's assistant, also noticed another remarkable test of purity. As soon as the acid was no longer colored by the chloroform, the latter exhibits a strong convexity downwards toward the acid.

The process for purification proposed by Mr. Kemp is to agitate with strong pure sulphuric acid, allowing the liquid to remain in contact, with occasional agitation. Half its volume of acid will be enough, and if but little color is given, a second use of the acid is not needed, but this should be tried on a small portion in a test tube for greater certainty—the purification is finished with peroxyd of manganese, with which it is to be agitated and left in contact until the odor of sulphurous acid is removed.

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* This Journal, Jan., 1850, p. 115.

Redistillation is not required, in fact, is not necessary to the manufacturer, who has only to wash well the first product with water and purify as above.

As an instance of what the author considers the gross ignorance of persons pretending to manufacture such articles, he refers to a sample examined by him of sp. gr. about 1·000, and which seemed to have the following origin. The maker obtained two fluids from distillation, not knowing that the heavy one was chloroform he threw it away and put up the lighter, a mixture of pyroxylic spirit, its original impurities, the chlorinated oils and a mere trace of chloroform, and labelled it *pure chloroform*. Almost pure *from* chloroform, Dr. G. well says.

It is useless to call such conduct the result of gross ignorance, for in such cases a gross ignorance is gross rascality. G. C. S.

15. *On the preparation of Chlorate of Potash.*—Prof. F. C. Calvert, in a paper read before the Chemical Society of London, describes the following process as producing a maximum quantity of chlorate. The current of chlorine is passed into a solution of 100 fl. grs. containing 102·33 grs. anhydrous potash—its density 1·1. ·358 grs. quick-lime are to be added and the whole slightly heated. The result was 220 grs. of the chlorate beside about 20 grs. left in the mother water. The precise density of the liquid is important. G. C. S.

16. *Aspartic Acid formed from Bimalate of Ammonia*; by M. Dessaignes, (Comptes Rendus, March, 1850.)—Piria has proved that asparagine and aspartic acid are the amids of malic, as oxamid and oxamic acid are the amids of oxalic acid.* Succinic acid produced in the fermentation of asparagine has also been obtained from the fermentation of the malates in such quantities as to render the malates the best source of this hitherto rare acid.† Still all attempts at forming asparagine or aspartic acid from malic acid have failed, as chemists have not as yet succeeded in forming malic ether.

The author has however reached the desired end by the dry distillation of bimalate of ammonia. The residue with a heat of about 370° is a sparingly soluble amorphous reddish mass. Well washed with hot water this mass is changed into a very stable acid which however is not the aspartic. Heated for some time with hydrochloric acid this substance is no longer precipitated by water and yields on evaporation crystals containing hydrochloric acid which are easily purified. It is only necessary to dissolve these in boiling water, divide the solution, neutralize one-half in the ammonia and add the other half, to obtain on cooling a quantity of prismatic crystals of aspartic acid.

The form of aspartic acid thus obtained is not identical with that of the same acid from asparagine, but the salts are identical in form with the aspartates hitherto known. Analysis renders it certain that this is in reality aspartic acid.

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* This Journal, Nov., 1848, p. 420.

† Ibid, Jan., 1850, p. 117.

[Possibly the intermediate compounds above described may be an amid of one of the acids into which the malic is so readily transformed by heat—but as the anhydrid of malic acid is known, this acid would be the anhydrid of aspartic acid.] G. C. S.

17. *Stibethyle;* by C. Löwig and E. Schweitzer.—The authors decomposed "iodid of ethyl" by the alloy of antimony and potassium, formed according to Serullas' process by igniting antimony and cream of tartar. The decomposition is violent, and the product, *stibethyle*, is spontaneously inflammable—hence numerous precautions are required in manipulation. The formula given is $C_{12}H_{15}Sb$, which the authors regard "equivalent with antimoniuretted hydrogen in which three atoms of hydrogen are replaced by three atoms of ethyle," and hence conclude, that "*its composition presents nothing remarkable.*" They also regard it as a "radical" analogous to kakodyle.

Kakodyle has not held its ground as a radical, and the new substance must soon lose all claim to that title.

Stibethyle seems to form a fine crystalline salt with nitric acid, but the property of forming a salt with an acid has never been claimed as belonging to radicals, but to their oxyds.

The following view of the composition of this substance seems to be probable, and with due respect to its able and distinguished discoverers, we consider it as highly remarkable.

Antimony like phosphorus belongs to the nitrogen class and forms corresponding compounds. Antimoniuretted hydrogen is hence a sort of ammonia, we can hardly say ammonia with its nitrogen replaced by antimony, although this expression is used. SbH_3, or stib-ammonia, can take the place of NH_3. In the compound ammonias of Wurtz, that of the caproic series would be $C_{12}H_{15}N$. Stibethyle is then caproamine, in which antimony takes the place of nitrogen. The spontaneous inflammability of the new substance is owing to the presence of antimony, which in its relations to oxygen differs from nitrogen.

Wertheim has shown that by the action of hydrate of potash, narcotine yields C_6H_9N, or the compound ammonia of the metacetic series. We add a tabular view of the known compound ammonias, named according to the series to which they belong.

		Discovered by
Hydric, . .	H_3N	———
Formic, . .	C_2H_5N	Wurtz.
Acetic, . .	C_4H_7N	"
Metacetic, . .	C_6H_9N	Wertheim.
Butyric, . .	$C_8H_{11}N$	Anderson.
Valeric, . .	$C_{10}H_{13}N$	Wurtz.
Caproic, . .	$C_{12}H_{15}Sb$	Löwig and Schweitzer.

G. C. S.

18. *Action of Nitric Acid on Rhubarb.*—M. Garot (Journ. de Pharm. et de Chem., Jan., 1850) describes the result of the action under the name of *erythrosin*. From 10 to 20 per cent. may be obtained from the rhubarb. No analysis has been made—but there seems to be a mixture of rhubarbine of former authors and a nitric compound,

probably similar to acids derived from aloes by the action of nitric acid. Like these acids, erythrosin possesses high tinctorial power, and is recommended for its properties as a suitable dyeing material.

G. C. S.

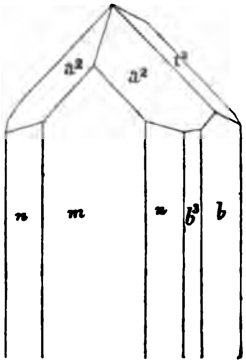
19. *On the Atomic Weight of Molybdenum;* by N. J. BERLIN, (J. f. pr. Chem., xlix, 444, 1850.)—From the analyses of three molybdates of ammonia, Berlin deduces for the atomic number of molybdic acid, ($\dddot{\mathrm{M}}\mathrm{o}$) as follows, 875·75, 876·57, 873·42, 873·25, affording the mean 874·75. He hence concludes that the number obtained for molybdenum by Svanberg and Struve, 575·83, based on 200 as the value of sulphur, must be right or very near the true one; and not 588·966, based on 200·75 as the value of sulphur. Hence also 200 is the true atomic number for sulphur.

II. MINERALOGY AND GEOLOGY.

1. *On a new Spodumene Locality at Norwich, Mass.;* by C. HARTWELL, Member of the Theological Institute of East Windsor, Ct., and E. HITCHCOCK, Jr., of Amherst, Mass.—This locality, in the north part of Norwich, was discovered by Mr. Eben Weeks of that place, and opened by the writers. The spodumene occurs in large veins of quartz, surrounded and partly intermingled with albite and feldspar, running north and south through a hill of mica slate. It has been seen for the most part in one large vein, which appears at the surface only in two places, about thirty rods apart. Associated with the spodumene, are crystals of staurotide of a new form, mica, imperfect specimens of beryl, and enormous black and blue tourmalines not perfect in figure. One vein, mostly albite, exhibits the spodumene in a decomposed state nearly as soft as gypsum. The spodumene is doubtless abundant, though a large quantity is not attainable without great expense. Crystals have been obtained with the breadth ranging from one-half inch to four inches, and some much larger are visible in the rock. It is usually massive in the albite, extended into the quartz in crystals, terminated at one end, and sometimes more than a foot in length. The longest individual that has been obtained measures eleven and a half inches. Much of the mineral has a beautiful pinkish hue. The crystals are usually opaque, but some are nearly translucent in parts. Good specimens are acquired with difficulty. One reason lies in the perfection of the cleavages, especially that parallel with the orthodiagonal, which renders them easily broken. Another lies in the nature of the gangue, as the quantity is full of rifts, rendering blasting difficult, and allowing access to the mineral for the weather, which has given it all a rusty appearance. The crystals can be cleaned by acid with no injury except perhaps a little damage to the lustre. The forms of the terminations are various. The crystal having the greatest number of planes, has been described in Dana's System of Mineralogy, 3d ed., p. 693, and now belongs to Prof. B. Silliman, Jr. Other crystals are similar in general form, but with a less number of planes. One of the specimens has only P wanting, and o', o'' are well developed. In others the plane a, o' and o'' are absent as well as P, as in the following figure; but the plane a is usually present.

The angles obtained with the common goniometer are as follows:—

m (back plane) : t^2=102° 30′–106°
n : t^2 =134°
b : t^2 =138° 20′
a : t^2 =148°
t^2 : t^2 (over the summit) =80° 30′
m : a^2 =116°
b : a^2 =134°
n : a^2 =144°
b^3 : a^2 =142°
b : a^2 =135°



The angle m : t^2 is generally about 102° 30′, although one crystal gave us 106°.*

The surface m in all the specimens, is finely covered with lines, as mentioned by Dana.

The new form of the staurotide occurring at the same locality,† gave us the following angles. (See figure, p. 121.)

P : t =131°
b^2 : b^2 (over b)=86°

This form is not usually found entire, but a few specimens have been obtained with only a slight imperfection. The plane P is frequently inclined from the true position, and often but one is found. In some individuals the plane b is nearly or quite obliterated by the planes N, in others it deeply truncates the crystal. Many of the crystals appear joined to the spodumene, in connection with which it usually occurs. The mineral is very brittle, and hence arises the difficulty of obtaining good forms.

2. *Age of the Nummulitic formation of the Alps;* (from the Address of Sir C. Lyell before the Geol. Soc., Quart. Jour. Geol. Soc., No. 22, 1850.)—In the chronological classification of the materials composing the crust of the earth, it has been often asked, whether we ought to ascribe to the older tertiary epoch, or to the cretaceous system, the great nummulitic formation of the Alps, and other parts of Europe. This much-controverted question,—one, as I shall presently point out, of the highest theoretical interest, in reference to the hypothesis of the unabated intensity of the existing agents of change,—was declared by M. Boué, some years ago, to be the great problem of the day, and Sir R. Murchison has therefore devoted to its consideration a large portion of his memoir. M. Boué indeed announced in 1847 his own conviction that the nummulitic rocks belonged to the eocene or lower tertiary period, and remarked, in a paper read to the French Geological So-

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* New measurements of several crystals recently received confirm this result. In one crystal, 109° were obtained; but in those of the best planes, using a cleavage surface for *m*, the angle obtained was 103°.— J. D. D.

† See last number of this Journal, p. 121.

ciety in that year, how much delight Alexander Brongniart would have experienced, had he lived to see one of his boldest and most startling generalizations thus crowned with success.* Al. Brongniart had in fact declared many years before, that the shells of the summit of the Diablerets, one of the loftiest of the Swiss Alps, which rises more than 10,000 feet above the sea, were referable to species characteristic of the eocene strata of the neighborhood of Paris. He only felt considerable hesitation, he said, in assigning to them so modern a date, because the overlying limestones were so compact and homogeneous as to agree in lithological character with much older secondary rocks.

Several of the most animated discussions which have taken place in this room since 1825, have turned, as you will recollect, on this subject, especially when the fossil shells brought by Mr. Pratt from Biaritz in the Pyrenees were laid upon our table. A decided opinion was then expressed by many of us that the nummulitic series of that southern chain must be referred to the lower part of the eocene group, as it was made clear that the proportion of fossil species common to the Biaritz beds and the chalk was extremely small—much too small to imply a cretaceous age for the strata in question, or even a zoological passage from the cretaceous to the tertiary formations. They who have read with care the successive numbers of the 'Bulletin' of the Geological Society of France, are aware how much that body has been occupied with the same problem, and how steadily the evidence in favor of the same important conclusion has been gaining strength. M. d'Archiac, writing in 1847 on the fine collection of Biaritz shells submitted to his inspection by Mr. Pratt, observed that forty-eight, or one-fourth of the whole series, were identical with fossils of the lower eocene of the Paris basin, while the rest were all tertiary forms except four, which belonged to species of the chalk.† In a paper by M. Deshayes, read to the Geological Society of France in June, 1844,‡ that able conchologist declared, after examining the Biaritz fossils, "that the whole of the nummulitic system must be classed as tertiary; an opinion confirmatory," he said, "of the results previously arrived at by M. Leymerie in the Corbières, and of M. Bertrand Geslin in the Alps." Lastly, I may observe, that you will find similar opinions recorded in the 'Bulletin,' either in the memoirs or verbal comments of MM. Deshayes, Charles Desmoulins, Raulin, Leymerie, Tallavigne, Delbos, Desor, Boué, Archiac, and Alcide D'Orbigny, all published in the course of the last six years. Whether a real transition from the cretaceous to the tertiary strata can be made out, is a point which has also been fully discussed, and how far the Maestricht beds are represented in the Pyrenees. It appears from the researches of MM. Desmoulins and Raulin, that some few of the characteristic fossils of Maestricht have really been found in that chain; but you will, I think, agree with M. Deshayes, that they are not enough to establish the existence of any true equivalent of the Maestricht group—that distinct and uppermost division of the chalk to which the Faxoe coralline limestone in Seeland, as well as the pisolitic strata of Sezanne near Paris, are referable.

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* Bulletin, vol. v, 2nd series, pp. 69, 71.

† Bulletin, vol. iv, 2nd Series, p. 1006.

‡ Translated in Quart. Journ. Geol. Soc., 1845, p. 111.

When we consider that the age of the nummulitic formation of the Pyrenees, however clearly it may now be determined to be tertiary, has been regarded by so many able authorities as a subject of perplexity and debate up to so late a period, we cannot feel surprised that MM. De Beaumont and Dufrénoy, in constructing their geological map of France many years before, should have referred these strata in the Alps, and in the regions bordering the Mediterranean, to an age anterior to the calcaire grossier of Paris, especially when we learn that even now M. Agassiz affirms, that out of 139 species of echinoderms described by him from the nummulitic beds of the Mediterranean, one species only is common to them and the calcaire grossier. The same geologist maintains that all the fish of Glarus and Monte Bolca, which according to the latest opinions must be classed as eocene, differ entirely from those of Sheppy.* Yet I am by no means disposed to question, on the ground of this want of agreement in the ichthyolites, that the Glarus slates are in truth tertiary, still less to doubt that the limestone of Monte Bolça belongs to the same period: I have always regarded the latter as eocene from the time when I visited that locality in company with Sir Roderick Murchison in 1828. You have seen also, in the classification of the three successive eocene formations established by Mr. Prestwich for the older tertiary deposits of Great Britain, that while each division is characterized by its peculiar assemblage of shells, a part only of the species pass from one division to another, and that the specific difference of the mammalia belonging to each division, and still more of the first, as determined by Agassiz, is extremely marked.

The researches, above alluded to, of Sir Roderick Murchison in the Alps in 1847, and the palæontological evidence of various eminent writers brought together by him in illustration of his views, have, I think, shown unequivocally, that, together with the nummulitic limestone, an enormous thickness of overlying strata of dark-colored slates, marls, and fucoidal sandstones, provincially called Flysch, are separable from the cretaceous system of Northern Europe, and must also be regarded as lower eocene. His attempt however to make out a passage from the tertiary to the secondary series by means of an intervening group of marls, green sandstone and impure limestone, appears to me to be far less successful, since a true representative of the Maestricht beds is wanting in the Alps, or is very ill-defined, and no other equivalent assemblage of organic remains is enumerated sufficiently rich in forms, or intermediate in character, to fill up the wide gap between the eocene strata and the chalk.

I have dwelt thus at length on the age of the nummulitic series, because its recognition as a tertiary deposit draws with it consequences of the utmost theoretical importance, and is singularly confirmatory of a remark made by M. Desnoyers many years ago in his address to the French Geological Society, namely, "that the more the Alps are studied the younger they grow." This saying was elicited by the admission by competent observers, that certain schistose rocks of great thickness, containing dark writing slates, originally classed as "transition formations" by some of the followers of Werner, and regarded as of palæozoic age, were really secondary. Now we are called upon to go much further; for these same strata belong to the flysch, and therefore constitute what is by no means the base of the eocene system. To the English geologist who is old enough to remember when all the soft clays and loose sands overlying the chalk, some of them containing shells of species identical with those now living, were looked upon as very modern, and as the creations of yesterday, in comparison with the rocks of the higher Alps, it may well appear a startling proposition to learn that the clay of London was in the course of accumulation as marine mud at a time when the ocean still rolled its waves over the space now occupied by some of the loftiest Alpine summits. It will follow, moreover, as a corollary from the same data, as before hinted, that not only the upheaval of the Alps, but all the principal internal movements, dislocations, inversions and contortions of the strata, are subsequent to the origin of the nummulitic deposits, and had not therefore even commenced till great numbers of the eocene vertebrate and invertebrate animals had lived and died in succession.

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* Bulletin, vol. v, pp. 414, 415.

3. *On the Geographical Limits of the Chalk Formation;* by Leopold von Buch, (from the Monatsberichte der Akademie der Wissenchaften zu Berlin, für 1849, p. 117. Compare also, Betrachtungen über die Verbreitung und die Grenzen der Kreide-Bildungen, Bonn, 1849. Aus den Verhand. des naturhist. Ver. der. Pr. Rheinlande; cited from the Quart. J. Geol. Soc., No. 21.)—The small extent towards the poles which the chalk formation attains, compared with the Jurassic strata, and still more with the palæozoic deposits, has been regarded by Dr. Boué, not without some probability, as the most ancient known effect of the influence of climate on the fauna of former worlds. In reality the most northerly point on the whole earth in which chalk has as yet been found is, according to Prof. Forchhammer's determination, in the vicinity of Thistedt in Jutland, not quite in 57 degrees of latitude, or in that of Aberdeen in Scotland, of Calmar, Mitau, Twer and Casan. In the British islands the chalk does not reach so far north; the last appears on the south coast of the island of Rathlin near the Giant's Causeway, in the latitude of Apenrade, of Bornholm and of Tilsit. Flamborough Head in 54° is its last appearance in England. In Russia this limit always sinks deeper towards the south. From Grodno, where the chalk still appears in 54°, it runs, as laid down in Murchison's masterly geological map, through Mohilew and Orel, a degree and a half of latitude south of Moscow, and from Simbirsk downwards along the Wolga, even to the Caucasus. MM. Murchison, Verneuil and Keyserling have very unexpectedly discovered this chalk on the banks of the Ural river, ninety English miles below Orenburg, in 51½°. The Muchodjar mountain determines its limits towards the east. The immense extent of Siberia from the Ural to Ochotzk, and from the Altai to the Icy Sea, has now been so minutely and carefully examined by so many mining engineers, naturalists and gold-seekers, that we may well doubt the occurrence of cretaceous beds in this whole region.

Everywhere along this border, only the upper chalk appears, the strata so peculiarly characterized by *Gryphæa vesicularis*, *Belemnites mucronatus* and *mammillaris*, by *Inoceramus Cuvieri* and *Cripsii*, by

Ostrea Diluvii, *Terebratula carnea* and *semiglobosa*, by *Ananchytes ovata*, *Galerites vulgaris* and *albogalera*, and similar fossils. Older cretaceous strata first appear only in proportion as we descend towards the south, and in the Caucasus, in Daghestan, these older (*neocomien*) beds, according to the excellent observations of Abich, attain a thickness of nearly 5000 feet. It resembles a mighty wave, sweeping far down from the highest summits of the Caucasus and gradually dying away on the margin of the older formations in the plain [on the north].

Beyond the ocean the cretaceous formations terminate in the Atlantic regions of the United States before they have reached the city of New York, so that their limit scarcely touches the 40th degree of latitude, or sixteen degrees lower than in Europe. In Kentucky and Tennessee it remains below 37°. But it is very different far up on the Missouri; this great river flows uninterruptedly from the foot of the Rocky Mountains for 1400 English miles, through strata of chalk, at least as far as the mouth of the Sioux river. This is the result of the accounts and collections of the Prince of Neuwied and of the reports of the celebrated astronomer Nicollet. In these western parts of America therefore, the chalk formation rises to 50° of latitude, or full ten degrees higher than in the eastern portion. Here also it shows a continuous extension greater than that of any other formation known on the surface of the globe. Captain Fremont saw chalk strata, fields covered with *Inoceramus Cripsii*, on the river Platte, Lieutenant Abert on the Arkansas, and as far as Santa Fe in New Mexico, and Dr. Wislizenus found them also beyond the Rio del Norte near Monterey and Laredo, according to the reports published in 1848 by the Congress at Washington. The Rocky Mountains and their continuation to the east [west?] of Santa Fe in New Mexico, have entirely cut off this cretaceous sea. No trace of chalk was discovered either by Captain Fremont on the Columbia river, or on the Humboldt river in the wonderful "Great Basin" down to the Pacific, or yet by the observant Captains Cooke and Johnston in Sonora and California along the Rio Gila.

Nevertheless the whole of this so vastly extended chalk formation consists only of the upper beds. After very careful and accurate investigation, Sir C. Lyell decided, that in the whole of North America chalk strata from the Maestricht beds down to the gault alone occurred; and Mr. Ferdinand Römer, as the result of his highly valuable and accurate researches in Texas, goes the length of considering all the strata in that region, already so far removed from the Atlantic coast, as entirely of the upper division, and not even once touching on the gault.

This peculiarity is, however, singularly enough limited to North America alone. Even in Mexico deeper beds already appear to occur.

M. Galeotti has brought Trigoniæ from Tehuacan, on the borders of the province of Oaxaca, which he has described as *Trigonia plicatocostata*.* This *Trigonia* belongs to the division of the *Trigoniæ Scabræ* of Agassiz, and differs but slightly from *Trigonia aliformis*, Sow.

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* Bulletin de Bruxelles, iii, No. 10.

The latter is however characteristic of the middle chalk, *craie chloritée*, as also of the gault. In the middle of the chief Cordillera of Anahuac, twelve French miles northwest from Tehuacan, this shell is so universally abundant and large that it may be regarded as the distinctive mark of the entire formation. One is astonished, he says, to find such immense accumulations of fossil shells, so many fragments of ammonites several feet in diameter, or of gigantic coral stems in this place, so much so that there is perhaps no other place on the surface of the globe where such an enormous mass of organic remains lies scattered over many square miles. Now this *Trigonia* appears again in South America in the mountains of Santa Fe de Bogota, from which M. von Humboldt first brought it to us. The organic remains enclosed in the strata of these mountains of Santa Fe de Bogota prove most decidedly the occurrence of the middle chalk, as I have endeavored to show in the description of Humboldt's collection of American petrifactions (Berlin, 1839), and as Alcide d'Orbigny has still more fully proved in his no less instructive than masterly work on M. Boussingault's collections. But as the cretaceous formations in New Grenada attain a thickness of more than 5000 feet, it is not surprising that the organic remains of the lower cretaceous strata, or the *neocomien*, should also be found in this place. D'Orbigny has described an *Exogyra* from Socorra, which is not distinct from the *Exogyra Couloni* of the *neocomien*. Many specimens of this same *Exogyra* were collected by the late Dr. Meyen on the declivities of the volcano of Maypo in Chili at the height of 13,000 feet, and (badly) figured.* Darwin also† found it on the Portillo Pass in the Peukenes chain, not far from Maypo, but also sixty English miles further north on the Uspalata Pass. The *Exogyra Couloni* or *aquila* is, however, a true and very decided characteristic shell for the *neocomien.*

The fossils collected by Darwin in the mountains above Copiapo, and Coquimbo in northern Chili, and those which Domeyko, Professor of Mineralogy in Coquimbo, has sent to Paris, again belong to newer cretaceous strata, and are found in part also at a distance from it beyond the great knot of transition beds which, along with older rocks, have intruded into the chain of the Andes.‡ The most remarkable of these forms is the beautiful univalve, which Humboldt first brought from San Felipe in the south of Quito, near the Amazon river, and which was figured and described by me as PLEUROTOMARIA HUMBOLDTII in the 'Petrifactions,' v. f. 26, first published in 1839. D'Orbigny, followed by Darwin, names it "*Turritella Andii*," but whether correctly is still very doubtful. It appears peculiarly characteristic of the whole southern districts of America. Darwin has found it in abundance in the strata of Coquimbo, on the Rio Claro and near Arqueros, and in like manner above Guasco and near Las Amolanos in the principal valley of Copiapo. This *Pleurotomaria* is always conjoined with the *Pecten*, occurring even in the northern regions between Montan and Guancavelica in such incredible numbers, that it forms fields, nay, mountains of petrifactions, long and very generally known to the natives under the name of "*Choropampas.*" (*Pecten alatus*, Dufresnoyi, d'Orb.) It was this shell also that, in 1761, excited so great astonishment in Ulloa at the great elevation above the level of the sea, at which mountains composed of shells were seen, and this astonishment was repeated in all text-books, till it was discovered that the shells had not necessarily lived at this elevation, but might have been raised up from the depths of the sea. Since *Hippurites organisans* (D'Orb., p. 107, t. 22) occurs with the pecten-strata, it is evident that all these beds in Peru, as at Coquimbo and Copiapo, must be conjoined at least with the gault; a result which is most strikingly confirmed by an *Exogyra* which M. Domeyko has sent to Paris. This is indeed perfectly identical with the *Gryphæa* (*Exogyra*) *Pitscheri* from Texas, already described and figured by Morton, and the position of which above the gault at Friederichsberg has been very accurately ascertained by Ferdinand Römer.

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* Acta der Leopold. Academie, vol. xvii, pt. ii, p. 649, t. 27, f. 5.

† Geol. Observations on South America, 1846.

‡ "Beyond and north of the great shut in mountain-basin of Titicaca, composed of older rocks, the trias and carboniferous limestone." (Bet. über die Ver. der Kreide-Bild., p. 27.)

Lower cretaceous strata, similar to those of Aconcagua, are nevertheless not altogether unknown in the Andes mountains near Lima. The celebrated zoologist von Tschudi has found, on the eastern declivity of the mountains, between Oroja and Yauti, near Tarma, along with many others, some perfectly characteristic neocomien shells:—*Pterocera Emerici*, (D'Orb., p. 216,) *conoidea*, Goldfs.; *Holaster dilatatus* and *Holaster complanatus* or *Spatangus retusus*, both identified by Agassiz; *Diadema Bourgeti*, also determined as such in Neufchatel; *Pecten cretosus*, Brgnt. and *Pecten quinquecostatus.*

According to this, the cretaceous formation in South America appears to be developed in an entirely different manner, in much greater thickness and variety than to the north of the Gulf of Mexico, and the agreement with the European cretaceous strata is also much more complete in the Andes. It is, however, highly remarkable, that in North America the cretaceous strata are spread out quite horizontally over immense spaces, and that they consist chiefly of clay and sand, and other slightly coherent masses. In South America we only see black limestones or compact sandstones, of such consistence, that one often believes them to be pure quartz, as between the Maranon and Lima; along with this, the strata are never horizontal, but always more or less inclined; a disturbed position which they evidently can only owe to powerful disturbing forces. There can be less doubt in regard to this, when it is seen, as Meyen informs us, that the precipitous cone of the Volcano of Maypo consists for two-thirds of its height of chalk rich in petrifactions, and that throughout the whole of Chili masses of gypsum, many thousand feet thick, surround the volcanos, and the cretaceous strata first appear quite above them. But when we leave this desolation, the chalk also has vanished. It never reaches the plain of the Pampas on the east; a chain of Devonian strata at the eastern foot of the Andes does not permit it even once to touch on the outskirts of the vast plains of the Pampas. As little can it extend westwards towards the Pacific Ocean. A considerable elevation on the mountains must be attained before it is met with. What then can induce the chalk to run along, only in the direction of the high mountain ridge of the volcanos, and only in a narrow band, and never to descend into the plains!! In the whole of Brazil, in the wide regions of La Plata, Paraguay, Bolivia, the chalk is never again seen, and indeed does not exist. Is it not like a band of chalk which has been formed along the volcanic fissure of the Andes before the mountains were elevated, perhaps because the slightly concealed fissure had produced the conditions of life and existence for the cretaceous mollusca on a more extensive and easily attainable scale?

Darwin has followed the cretaceous strata to the extreme point of the continent. He saw cretaceous shells in abundance on the top of Mount Tarn 2000 feet high, near Port Famine in the Straits of Magellan, and in 53 degrees of south latitude, and consequently three degrees of latitude higher than on the Missouri. *Ancycloceras simplex*, d'Orb., and *Hamites elatior*, Sow., leave no doubt of the chalk. The Hamite is even, says Prof. Edward Forbes, one of the largest ever seen, fully 2½ inches in its largest diameter. Darwin's discovery probably determines the most southern limit of the cretaceous formations; and hence polar influences may have here also opposed its further extension towards the Pole. J. N.

III. ZOOLOGY.

1. *Contributions to the Natural History of the Acalephæ of North America;* by L. AGASSIZ: Part I, on the Naked-eyed Medusæ of the shores of Massachusetts in their perfect state of development, (Transactions of the American Academy of Arts and Sciences, 2nd Series, Vol. III, Part I, Article IX, pp. 221 to 316, 4to, with 8 plates.)—Professor Agassiz, in this paper, gives his readers Part I. of his researches on the Medusæ of the American Coast. His investigations have brought to light much that is new and of deep interest to science: and they are illustrated by beautiful as well as faithful engravings. The species described are *Sarsia marabilis*, *Hippocrene superciliaris*, *Tiaropsis diademata*, and *Staurophora laciniata.*

Prof. Agassiz, in the course of his memoir, makes some observations on the classification of these animals, and gives reasons for including all the naked-eyed Medusæ in one family. He points out the little importance to be attached (except for generic and specific distinctions) to the number of tentacles, and the position of the ovaries in these Medusæ. The grand characters of the group or family are as follows:——consisting of a gelatinous disk with the margin re-entering so as to form a cavity beneath;—a central digestive cavity, from which tubes, carrying chyme and forming a chymiferous system, radiate towards the margin and connect with or pass into a circular tube situated near the margin;—tentacles and eye-specks along this margin; mouth central but varying in size and form;—reproductive organs following the chymiferous system;—a nervous ring adjoining the submarginal chymiferous tube;—generation alternate, one form Polypoid, and the other Medusoid.

Among the species described, we select for particular notice the *Hippocrene superciliaris*, the observations on which embrace the principal points determined by the author. This beautiful Medusæ is a globular bell-shape animal with 4 bunches of tentacles on the lower margin. In the inner cavity of the bell, at centre, there is a dark four-sided mass, containing the mouth and digestive cavity, about as broad as long. In some species, as the genus *Sarsia*, this mass is elongated into a movable proboscis, in others it is scarcely projecting. From its angles, in the Hippocrene, proceed internally four tubes which carry from the digestive cavity the chyme or fluids after digestion, diluted with more or less of the external waters; these tubes pass to the border and here connect with a circular tube which follows the margin around, and in which the chyme continues its course. This, as Prof. Agassiz explains with many details, is the circulating and digestive system combined, of this and other species of the family. The tubes may be closed at their connection with the stomach, "showing that the food is not admitted before it has undergone a certain degree of elaboration; but no sooner has it been reduced to the requisite degree of fluidity, in which the particles of the nourishing materials appear like little globules, than they open, the nutritive fluid passes into the radiating tubes, circulates regularly through these tubes along the inner walls of the disk, and through them passes into the circular tube around the lower margin." Prof. Agassiz observes that while the circulation is properly a *chyme* circulation in these animals, it is a *chyle* circulation in Articulata and Mollusca, and in Vertebrata alone, *true blood.* The particles in the circulating fluid of these Medusæ are very irregular in size and color and are evidently only the imperfectly digested food.

The *nervous cord*, as distinctly made out by Prof. Agassiz, follows the circular submarginal tube on its inner side, and like that, is a complete ring. At the base of the cluster of marginal tentacles there is an enlargement or bulb-like prominence. Each tentacle contains within its base a black point which subserves the purpose of vision. The bulb is not hollow in the Hippocrene, but contains an enlargement of the nervous cord, which, as our author shows, may be considered a ganglion, although not purely nervous matter in its constitution, and this position of the ganglion has a direct relation to the organs of sense clustered near it. The nervous cord, under a high magnifier, appeared as a string of several rows of nucleated ovate cells, ranging in irregular lines, the cells not strictly in juxtaposition by their ends, but alternate more or less, so as to form a cord-like mass; and it was distinctly observed passing into the angles of the sensitive bulbs. The dark spot of the bulb consists of pigment cells, which point to the centre of minute black eye-specks, showing a close connection between these dark dots and the centre of the bulb where the nervous ganglion is seated; "and though this is not an arrangement known in the organs of vision of any other animals, we are at least reminded by these peculiarities of the structure of the compound eye of insects, in which the pigment pillars intervening between the nervous mass at the base of the eyes present a structure not very different from that of the radiating cones in the bulb of the Hippocrene."

There is a similar ganglion in each of the four bulbs. A branch of the nervous thread, or what appeared to be a continuation of it, was detected along each chymiferous tube leading upward towards the digestive cavity; and above, near where these tubes bend towards this cavity, the cord passes around so as to form a circle, about the upper part of the chymiferous system or near the centre of the disk. There is thus a marginal, and (if there be no mistake as to its nervous character,) a central circle to the nervous system; from the latter at a point half way between two chymiferous tubes a branch passes off and descends to the buccal or digestive mass below, and other branches go to the inner muscles. Professor Agassiz observes that there is a difference between the cord of the lower margin and the other threads, and he was not fully satisfied of the real nature of the latter. Instead of consisting of distinct cells, they are thin threads in which the cellular appearance is almost gone, excepting where they combine to form a plexus in which some of the threads have the form of long caudate cells: they differ from muscular fibres as much as they do from the main nervous cord. No contraction was observed in them; this fact, and also their connection with the chymiferous tubes and the sensitive bulbs below,—the nature and position of the plexuses as well as their branching to the digestive organ and to the muscles—favor the view taken. The close juxtaposition of the chymiferous system —the source of nutriment—with the nervous system and the sensitive bulbs and eye-specks, is remarked upon as a fact of much interest.

The muscular system is minutely developed in this memoir and well brought out in the figures. The muscles consist of contractile cells, rather than of fibres. Over the surface of the bell-shaped part of the disk, the epithelium consists of irregular polygonal cells, of very faint outline, hardly distinguishable except by a kind of mosaic arrangement seen by means of their granular contents. On the sides and above the disk as well as on the inner surface of the main cavity, these cells are more regular and distinct. The network of muscles, or rather lines of contractile cells, beneath the epithelium extend in two main directions; the main bundles being vertical, four in number, and alternating with the chymiferous tubes; and the others transverse circular, in four narrow ranges, but with others smaller and less regular. The fibres are chiefly superficial though penetrating somewhat into the gelatinous disk. In the inner cavity, there are four vertical muscular bundles, ranging between the chymiferous tubes, which terminate midway between the sensitive bulbs; and also eight others much smaller, alternating by twos with these four. This same cavity has a transverse layer of contractile cells lining the whole interior, as was distinctly observed on close examination. It properly consists of four parts, extending from one chymiferous tube to another. There is still another muscular system extending between the four sensitive bulbs, within the lower margin, which is made up of a thick layer of muscular fibres, with which alternate some few radiating fibres, crossing the former at right angles and most numerous about the eye-specks.

It is now well known that these Medusæ in one stage of their existence have a polyp form, and these Hydroid polyps are therefore only imperfect Medusæ. The Sarsia in one of its conditions is a *Coryna*, and the species of Coryna pertaining to the *Sarsia mirabilis* (although not figured in this memoir, which treats only of these animals in their perfect state of development) is well known in the Boston Harbor and has been often collected by Prof. Agassiz. The polyp of the Hippocrene is still unknown: but we have here the suggestion, with some good reasons for admitting its correctness, that it is a *Tubularia*, a fine species of which is well known in the same harbor.

Many other points are detailed in this memoir which we have to pass by at this time.

Besides the species mentioned as described in this paper, the author briefly mentions two new species of *Thaumantias* (T. diaphana and T. pilosella); and also a new genus near Hippocrene which he calls *Nemopsis*, in allusion to the fact that two of the eye-specks of each cluster have a slender pedicel instead of being sessile like the others near the bases of the tentacles. The species was taken in Nantucket Harbor, June, 1849, and is named *N. Bachei.*

2. *On the Structure of Nummulina;* by W. B. Carpenter, M.D., F.R.S., (Quart. J. Geol. Soc., No. 21, Feb. 1, 1850.)—In this elaborate and well illustrated memoir, Mr. Carpenter sustains the opinion that the Nummulites are true Foraminifera. The succession of cells in a spiral order was pointed out by D'Orbigny as favoring this view. Carpenter remarks also that the cells or chambers are not even and regular as in the chambered shells of the cephalopodous mollusks, but irregular and of varying size, and hence infers that the cells must have corresponded to separate individuals, like the polyps of a compound coral zoophyte, and that they were the result of successive gemmation. The septa are found under a high lens to be double, each cell having its own proper wall. A distinct perforation passes through the septa, as observed by D'Orbigny, and still more minute apertures, varying in number and position, exist on the surface of each septum penetrating, however, only a single wall. The successive whorls of the Nummulite are well known to envelop and invest completely each the preceding, so that in a vertical section each chamber of the medial plane is seen to be covered with as many layers of shell above and below its own roof and floor, as there are chambers intervening between it and the nearest margin of the sections. A series of perforations were detected by Carpenter, extending from the exterior directly downwards until they reach the roof and floor of the central plane which they do not penetrate. They terminate over the septa and pass actually into the *interseptal spaces*, which have numerous communications with the chambers themselves. Thus there is a direct communication of a tubular character between the interseptal spaces of the central plane and the external surface, so that all these spaces communicate with the medium, which the animal may inhabit. "In the *Nummulina complanata* and other species in which each investing whorl is in contact with the one it encloses, except at its edge, the perforations have the form of fissures, that correspond with the subjacent septa, towards which they directly pass." These fissures are usually found to be filled with opake matter; and the dark bands thus formed in a transparent section are seen to be crossed by delicate white lines, which seem to indicate a division of the fissure into a number of tubes of irregular form, probably for the passage of pseudopodia. The animal segments of the several cells though distinct have a connection by fibres or tubes, and it is probable that the inner whorls retained their vitality, although so deeply inclosed,

and absorb their nourishment probably by means of filamentous pseudopodia projecting through the system of passages leading from the medial plane to the inner surface.

The memoir contains also the results of a microscopic investigation of the Orbitolites, showing their relation to the Nummulites, and also observations upon the Orbitoides, indicating that they also are Foraminifera.

IV. MISCELLANEOUS INTELLIGENCE.

1. *On the Negro Races of Oriental Africa;* by M. SERRES, (L'Institut, No. 857, June 5, 1850, from the Proceedings of the Academy of Sciences of Paris, June 3, 1850.)—M. Serres read a report on the negro races of Oriental Africa, south of the equator, observed by M. de Froberville. The conclusions of the report are as follows:—That the gradation or degradation of the physical characters of the Ostro-Negros justifies in all points the divisions which the author has laid down;—that among these characters, the prognatism of the maxillaries, the thickness and prominence of the lips, the woolly or frizzled tendency in the hair, the shades of color in the skin, are particularly and properly brought out;—that with regard to the prognatism of the maxillaries and the peculiarity of the lips "en forme de boudin," there is a regular gradation from the Congo-Guinea negro to the Eastern Oceanic negro, and from these to the Caffro-Bechuans, and these last graduate into the Semitic mongrels in those physical conditions where they are observed in some branches of the Caucasian race;—that this gradation of characters, of so much interest in the study of the races of men, is well sustained by a comparison of the busts executed by M. de Froberville, and better still by the portraits obtained by means of the daguerreotype by Dr. Jacquart;—that the existence of a type uniformly disseminated among the negro tribes distributed south of the equator to the gulf of Mozambique having close relations to the Semitic type is a fact of great interest in anthropology;—that this interest is independent of the Phenician origin which M. de Froberville attributes to it, and which at present is only an hypothesis;—that the repetition of an oceano-negro type among one of the groups of Oriental Africa is also a most curious result bearing upon the affiliation of races, in spite of the disagreement which exists in this subject between ethnology and anthropology;—that, finally, from the analysis and comparison of the physical characters of the Ostro-negros, the conclusion of the author is obvious and decisive, that "the more thoroughly and comprehensively the Congo-guinean, Caffro-bechuan and Ostro-negro races are studied, the more distinctly does the unity of the human race come out as an established principle in science.

2. *Fabrication of Zinc compounds not injurious to health.*—At a meeting of the Academy of Sciences at Paris in June last, M. Sorel, replying to some authors who at preceding sessions of the Academy had made observations tending to show that zinc was not innocuous, stated that for fifteen years he had employed in his establishments for the galvanization of iron several hundred workmen, a large number of whom were occupied with pulverizing and sifting the gray or suboxyd of zinc, for galvanic painting, and in no instance had any of the work-

men of the establishment, although in the midst of an atmosphere containing much of the oxyd, suffered at all from it. The white oxyd of zinc had also been fabricated for some months, without any ill effects, although the men breathe considerable quantities of the oxyd.

3. *Anchor-Ice;* by Prof. C. Dewey.—Water sometimes freezes upon stones below the unfrozen surface of the water. Fastened in this way, it passes under the common name of *anchor-ice.* As soon as the ice is detached, it rises to the surface and floats upon it. In explaining this phenomenon, it has been said, that in thus freezing, the water parts with its latent caloric to the stone and crystallizes upon it, and that its crystals are then *heavier* than water. The first part of this solution is only a statement of the fact in chemical language, and the last part is opposed by the fact that the detached ice uniformly and directly rises to the surface.

The observed facts are the following. Anchor-ice forms in still or running water, and often where the current is rapid; on stones of quartz, granite, mica-slate, or limestone, and on wood fresh or old under water; in masses from less than an inch to two or three inches thick, over stones several inches in diameter as well as on smaller ones; of a spongy or fibrous appearance under the water, but composed of flat irregular crystalline plates or tables, with regular angles and terminations, cohering or strung along upon each other, exceedingly white and beautiful; when the surface of the water is free from ice, and the *temperature of the whole is at the freezing point* as shown by the thermometer, and the atmosphere is below the freezing point several degrees; when none is on the stones at sunset, they are covered in the morning after a clear and cool night. This ice begins to leave the stones in the morning, and before noon has all risen and disappeared, often covering the whole surface of the water for some time. Repeated instances of these various particulars were observed by me in the latter part of March last, in Queechy River, at Woodstock, Vt., a stream there three to six rods in width and of variable depth. The stones lay loose on the bottom, often on sand, and had no connection with rocks which sometimes extended from the bottom to air or to the frozen earth in the banks out of the water. This ice was formed all along the bottom, probably for miles where the same circumstances occurred. I saw it also on wood under water, and in one instance on a piece fresh sawed from a log of hemlock. The depth to the ice (below the surface of the water) was from a few inches to three feet, and the water sometimes nearly still and at other places in rapid motion.

The principle of this phenomenon is probably the same as the following.

Saturated solutions of some salts, as sulphate of soda, at a high temperature, may be gradually cooled at rest without depositing the salt. The agitation of the cooled solution, on putting a rod of glass, wood or metal into it, commonly, but not *always*, causes the deposition of the substance. A crystal dropped into the solution directly begins the crystallization of the salt. It is well known that water may be cooled in a still vessel below 32° without freezing, but a little agitation produces congelation of a part of the water in long fibrous or laminated crystals.

The stream of water is cooled to the freezing point, and by the cold of the night its temperature is still more reduced. In this state the caloric is more than saturated, and the stones and wood under the water perform the part of the crystals or rod in the solution of salt, and the ice forms upon them.

The quantity of anchor-ice formed would be small for an obvious reason. Every pound of water frozen would evolve 142° of caloric, which would raise 142 pounds of water one degree, or 71 pounds two degrees. Allowing the temperature of the stream to be reduced to 31° or 30°, the congelation of a relatively small quantity would thus prevent the further congelation, while the crystals of ice would be formed under water where the solid bodies, as wood or stone, are.

Considering how poor a conductor of caloric wood is, it can hardly be supposed, that anchor-ice is formed on solid bodies merely because they are better conductors of caloric than water is, and the more so, because they must have the same temperature as the water.

Rochester, July, 1850.

P. S. Rocks sometimes pass from a frozen bank, by connection with which their temperature may be as low as 20°, into and under water, which congeals on them because they are so cold, and thus forms *solid* ice. This is not a case of anchor-ice, nor has it the form of that ice. When a rock, projecting from water, congeals the water into solid ice around it, this is not *anchor-ice.* To the first of these cases is doubtless to be referred that of James River, noticed in vol. xxxvi, p. 186 of this Journal. The explanation of it in vol. xli, p. 407, will hardly be considered applicable to real anchor-ice. It is probable that some of the ice in James River may be of the kind above described, though I have never seen it in *solid* masses, but of a spongy appearance. This form the anchor-ice retains after it has risen to the surface of the water.

4. *Discovery of the Great Lake "Ngami," of South Africa;* (Letfrom the Rev. David Livingston, addressed to the Rev. Authur Tidman, Foreign Secretary, London Missionary Society; dated, Banks of the River Zonga, 3rd September, 1849; cited from Jameson's Journal, July, 1850, vol. xlix, p. 156.)—*Dear Sir,*—I left my station, Kolobeng (situated 25° South lat., 26 East long.), on the 1st of June last, in order to carry into effect the intention, of which I had previously informed you, viz., to open a new field in the north, by penetrating the great obstacle to our progress, called the Desert, which, stretching away on our west, northwest, and north, has hitherto presented an insurmountable barrier to Europeans.

A large party of Griquas, in about thirty waggons, made many and persevering efforts at two different points last year; but, though inured to the climate, and stimulated by the prospect of much gain from the ivory they expected to procure, want of water compelled them to retreat.

Two gentlemen, to whom I had communicated my intention of proceeding to the oft-reported lake beyond the desert, came from England for the express purpose of being present at the discovery, and to their liberal and zealous co-operation we are especially indebted for the success with which that and other objects have been accomplished. While waiting for their arrival, seven men came to me from the Batavana, a tribe living on the banks of the lake, with an earnest request from their chief for a visit. But the path by which they had come to Kolobeng was impracticable for waggons; so, declining their guidance I selected the more circuitous route, by which the Bermangueato usually pass, and, having Bakwains for guides, their self-interest in our success was secured by my promising to carry any ivory they might procure for their chiefs in my waggon; and right faithfully they performed their task.

When Sekhomi, the Bermangueato chief, became aware of our intentions to pass into the regions beyond him, with true native inhumanity he sent men before us to drive away all bushmen and Bakalihari from our route, in order that, being deprived of their assistance in the search for water, we might, like the Griquas above mentioned, be compelled to return This measure deprived me of the opportunity of holding the intercourse with these poor outcasts I might otherwise have enjoyed. But through the good providence of God, after travelling about 300 miles from Kolobeng, we struck on a magnificent river on the 4th of July, and without farther difficulty, in so far as water was concerned, by winding along its banks nearly 300 miles more, we reached the Batavana, on the lake Ngami, by the beginning of August.

Previous to leaving this beautiful river on my return home, and commencing our route across the desert, I feel anxious to furnish you with the impressions produced on my mind by it and its inhabitants, the Bakoba or Bayeiye. They are a totally distinct race from the Bechuanas. They call themselves Bayeiye (or men), while the term Bakoba (the name has somewhat of the meaning of "slaves,") is applied to them by the Bechuanas. Their complexion is darker than that of the Bechuanas; and of 300 words I collected of their language, only 21 bear any resemblance to Sitchuana. They paddle along the rivers and lake in canoes hollowed out of the trunks of single trees; take fish in nets made of a weed which abounds on the banks; and kill hippopotami with harpoons attached to ropes. We greatly admired the frank, manly bearing of these inland sailors. Many of them spoke Sitchuana fluently, and, while the waggon went along the bank, I greatly enjoyed following the windings of the river in one of their primitive craft, and visiting their little villages among the reed. The banks are beautiful beyond anything we had ever seen, except perhaps some parts of the Clyde. They are covered, in general, with gigantic trees, some of them bearing fruit, and quite new. Two of the Boabab variety measured 70 to 76 feet in circumference. The higher we ascended the river, the broader it became, until we often saw more than 100 yards of clear deep water between the broad belt of reed which grows in the shallower parts. The water was clear as crystal, and as we approached the point of junction with other large rivers *reported to exist* in the north, it was quite soft and cold. The fact that the Zonga is connected with large rivers coming from the north awakens emotions in my mind, which make the discovery of the lake dwindle out of sight. It opens the prospect of a highway, capable of being quickly traversed by boats, to a large section of well-peopled territory.

One remarkable feature in this river is its periodical rise and fall. It has risen nearly three feet in height since our arrival, and this is the dry season. That the rise is not caused by rains is evident from the water being so pure. Its purity and softness increased as we ascended towards its junction with the Tamunakle, from which, although connected with the lake, it derives the present increased supply. The sharpness of the air caused an amazing keenness of appetite, at an elevation of little more than 2000 feet above the level of the sea (water boiled at 207½° thermometer), and the reports of the Bayeiye, that the waters came from a mountainous region, suggested the conclusion that the increase of the water, at the beginning and middle of the dry season, must be derived from melting snow.

All the rivers reported, to the north of this, have Bayeiye upon them, and there are other tribes on their banks. To one of these, after visiting the Batavana, and taking a peep at the broad part of the lake, we directed our course; but the Batavana chief managed to obstruct us, by keeping all the Bayeiye near the ford on the opposite bank of the Zonga. African chiefs invariably dislike to see strangers passing *them to tribes beyond.* Sebitoane,—the chief who in former years saved the life of Sechele *our* chief,—lives about ten days northeast of the Batavana. The latter sent a present as a token of gratitude. This would have been a good introduction; the knowledge of the language, however, is the *best* we can have. I endeavored to construct a raft, at a part which was only fifty or sixty yards wide, but the wood, though sun-dried, was so heavy it sunk immediately; another kind would not bear my weight, although a considerable portion of my person was under water. I could easily have swam across, and fain would have done it; but, landing without clothes, and then demanding of the Bakoba the loan of a boat, would scarcely be the thing for a messenger of peace, even though no alligator met me in the passage. These and other thoughts were revolving in my mind as I stood in the water,—for most sorely do I dislike to be beaten,—when my kind and generous friend Mr. Oswell, with whom *alone* the visit to Sebitoane was to be made, offered to bring up a boat at his own expense from the Cape, which, after visiting the chief, and coming round the north end of the lake, will become missionary property. To him and our other companion, Mr. Murray, I feel greatly indebted,—*for the chief expense has been borne by them. They* could not have reached this point without my assistance; but, for the aid they have rendered in opening up this field, I feel greatly indebted; and, should any public notice be taken of this journey, I shall feel obliged to the directors if they express my thankfulness.

The Bayeiye or Bakoba listened to the statements made from the Divine Word with great attention, and if I am not mistaken, seemed to understand the message of mercy delivered better than any people to whom I have preached for the *first* time. They have invariably a great many charms in the villages; stated the name of God in their language (without the least hesitation) to be "Oreeja;" mentioned the name of the first man and woman, and some traditionary statements respecting the flood. I shall not, however, take these for certain, till I have more knowledge of their language. They are found dwelling among the reed all around the lake, and on the banks of all the rivers to the north.

With the periodical flow of the rivers great shoals of fish descend. The people could give no reason for the rise of the water, further than that a chief, who lives in a part of the country in the north, called Mazzekiva, kills a man annually and throws his body into the stream, after which the water begins to flow.

The sketch which I enclose is intended to convey an idea of the river Zonga and the lake Ngami. The name of the latter is pronounced as if written with the Spanish ñ, the *g* being inserted to show that the ringing sound is required. The meaning is "Great Water." The latitude, taken by a Sextant on which I can fully depend, was 20° 20′ south, at the northeast extremity, where it is joined by the Zonga; longitude about 24° east. *We do not, however, know it with certainty.* We left our waggon near the Batavana town, and rode on horseback about six miles beyond it to the broad part. It gradually widens out into a Firth about 15 miles across, as you go south from the town, and in the south-southwest presents a large horizon of water. *It is reported* to be about 70 miles in length, bends round to the northwest, and there receives another river similar to the Zonga. The Zonga runs to the northeast. The thorns were so thickly planted near the upper part of this river, that we left all our waggons standing about 180 miles from the lake, except that of Mr. Oswell, in which we traveled the remaining distance; but for this precaution our oxen would have been unable to return. I am now standing at a tribe of Bakurutse, and shall in a day or two re-enter the desert.

The breadth marked is intended to show the difference between the size of the Zonga, after its junction with the Tamunakle and before it. The farther it runs east, the narrower it becomes. The course is shown by the arrow-heads. *The rivers not seen, but reported by the natives*, are put down in dotted lines. The dotted lines running north of the river and lake, show the probable course of the Tamunakle, and another river which falls into the lake at its northwest extremity. The arrow-heads show also the direction of *its* flow. At the part marked by the name of the Chief Mosing it is not more than 50 or 60 yards in breadth, while at 20° 7′ it is more than 100, and very deep.

The principal disease reported to prevail at certain seasons appears, from the account of the symptoms the natives give, to be pneumonia and not fever. When the wind rises to an ordinary breeze, such immense clouds of dust arise from the numerous dried-out lakes called salt-pans, that the whole atmosphere becomes quite yellow, and one cannot distinguish objects more than two miles off. It causes irritation in the eyes, and, as wind prevails almost constantly at certain seasons, this impalpable powder may act as it does among the grinders in Sheffield. We observed cough among them, a complaint almost unknown at Kolobeng. Musquitoes swarm in summer, and the Banyan and Palmyra give in some parts an Indian cast to the scenery.

(Signed) DAVID LIVINGSTON.

5. *Comparison of Fahrenheit and Centigrade Thermometers;* (L'Institut, No. 854, Acad. Sci., Paris.)—M. A. d'Abbadie observes that the usual formula for comparing Fahrenheit and Centigrade thermometers, ($C = \frac{(F-32°)\times 100}{180}$, when C and F represent respectively the degrees of the two thermometers,) supposes that 180° Fahrenheit just equals

100° of Centigrade; but in France the height of the barometer for graduation is 760 millimeters, while in England it is 30 inches, equivalent to 761·9862 millimeters. The Centigrade scale corresponding to 212° Fahrenheit is therefore 100·0727 degrees.

To this correction there is still another, (for instruments made at London and Paris,) amounting to $\frac{1}{10}$th of the preceding, which depends on the difference in the intensity of gravity at London and at Paris. Representing by G the force of gravity at Paris, and by g that at London, and deducing G and g from the observed length of the pendulum, we have, $\text{Log.}\ \frac{G}{g} = -1{\cdot}998797$. We hence obtain 759·785 millimeters for the height of the barometer at zero in London. The difference is equal to 0·215 millimeters or 0·0079 degrees.

These two corrections being applied, the Parisian scale should stand at 100·08066 degrees, when the London scale marks 212 degrees. The formula then becomes $C = \frac{(F-32°)\times 100{\cdot}08066}{180}$.

The correction is small; but in exact observations, the thermometer is read to 0·08 degrees; and it is desirable that even a slight error should not be added to errors of observation.

6. *Discovery of an Infusorial Stratum in Florida;* by Prof. J. W. Bailey.—While on a visit to Tampa (Fort Brooke), Florida, I noticed on the shores of Hillsborough Bay, between the mouth of Hillsborough River and Ballast Point, a white crumbling rock, which by its lightness, friability and other characters, somewhat resembled the Infusorial Marls of Virginia. An examination made upon the spot with a common Coddington lens enabled me to see small circular discs upon the freshly fractured surfaces, which subsequent examinations proved to belong to the genus Coscinodiscus. Numerous other marine species of Navicula, Gallionella, &c., together with numerous spicules of Sponges were recognized, although the highly indurated or lapidified condition of the strata rendered the determination of the species more than usually difficult. Of the precise geological position of this deposit I cannot be certain, but it is associated with strata containing fossils which appear to belong to the epoch of the eocene tertiary. This discovery of an extensive infusorial bed in a region so remote from those previously noticed in Virginia and Maryland, and apparently in an older geological formation will, it is hoped, lead to the examination of other localities, as it is not improbable that the deposit near Tampa may be a portion of a deposit as remarkable as those discovered by Prof. W. B. Rogers in Virginia and Maryland.

7. *On the Application of Magnetism as a Motive Power;* by R. Hunt, (Proc. Society of Arts, Athenæum, No. 1179, p. 588.)—In this paper the author called attention, in the first place, to the numerous attempts which have been made to apply electro-magnetism as a power for moving machines, and particularly described the apparatus employed by Jacobi, Dal Negro, M'Gauley, Wheatstone, and others, noticing incidentally the machines recently constructed by Mr. Hjorth. Since, notwithstanding the talent which has been devoted to this interesting subject, and the large amount of money which has been spent in the

construction of machines, the public are not in possession of any electro-magnetic machine which is capable of exerting power economically; and finding that, notwithstanding the aid given to Jacobi by the Russian Government, that able experimentalist has abandoned his experimental trials,—the author has been induced to devote much attention to the examination of the first principles by which the power is regulated, with the hope of being enabled to set the entire question on a satisfactory basis. The phenomenon of electro-magnetic induction was explained, and illustrations given of the magnetization of soft iron by means of a voltaic current made to circle around it. The power of electro-magnets was given, and the author stated his belief that this power could be increased without limitation. A voltaic current produced by the chemical disturbance of the elements of any battery, no matter what its form may be, is capable of producing by induction a magnetic force, *this magnetic force being always in an exact ratio to the amount of matter (zinc, iron, or otherwise) consumed in the battery.* Several forms of the voltaic battery were explained, particularly those of Daniell, Grove, Bunsen, and Reinsch, the latter being constructed without metals, depending entirely on the action between two dissimilar fluids, slowly combining. The author had, however, proved, by an extensive series of experiments, that the greatest amount of magnetic power is produced when the chemical action is most rapid. Hence, in all magnetic machines, it is more economical to employ a battery in intense action, than one in which the chemical action is slow. It has been proved by Mr. Joule, and most satisfactorily confirmed by the author, that one-horse power is obtainable in an electro-magnetic engine, the most favorably constructed to prevent loss of power, at the cost of 45 lb. of zinc, in a Grove's battery, in twenty-four hours; while 75 lb. are consumed in the same time to produce the same power in a battery of Daniell's construction. The cause of this was referred to the necessity of producing a high degree of excitement, to overcome the resistance which the molecular forces offer to the electrical perturbations, on which the magnetic force depends. It was contended, that although we have not perhaps arrived at the best form of voltaic battery, yet that we had learnt sufficient of the law of electro-magnetic forces to declare that, under any conditions, the amount of magnetic power would depend on the change of state—consumption of an element—in the battery, and that the question resolved itself into this:—

What amount of magnetic power can be obtained from an equivalent of any material consumed? The following were regarded as the most satisfactory results yet obtained:—1. The force of voltaic current being equal to 678, the number of grains of zinc destroyed per hour was 151, which raised 9,000 lb. one foot high in that time. 2. The force of current being, relatively, 1,300, the zinc destroyed in an hour was 291 grains, which raised 10,030 lb. through the space of one foot. 3. The force being 1,000, the zinc consumed was 223 grains; the weight lifted one foot 12,672 lb. The estimations made by Messrs. Scoresby and Joule, and the results obtained by Oersted, and more recently by Mr. Hunt, very nearly agree; and it was stated that one grain of coal consumed in the furnace of a Cornish engine lifted 143 lbs. one foot high, whereas one grain of zinc consumed in the battery lifted only 80 lbs. The cost of 1 cwt. of coal is under 9*d.*; the cost of 1 cwt. of zinc is 216*d.* Therefore, under the most perfect conditions, magnetic power must be nearly 25 times more expensive than steam power. But the author proceeded to show that it was almost proved to be an impossibility ever to reach even this, owing, in the first place, to the rate with which the force diminishes through space. As the mean of a great many experiments on a large variety of magnets, of different forms and modes of construction, the following result was given:—

Magnet and armature in contact, lifting force . .	220 lb.
" distant $\frac{1}{250}$ of an inch . .	90·6
" " $\frac{1}{125}$ " . . .	50·7
" " $\frac{1}{63}$ " . . .	50·1
" " $\frac{1}{50}$ " . . .	40·5

Thus at one-fiftieth of an inch distance four-fifths of the power are lost. This great reduction of power takes place when the magnets are stationary. The author then proceeded to show that the moment they were set in motion a great reduction of the original power immediately took place; that, indeed, any disturbance produced near the poles of a magnet diminished, during the continuance of the motion, its attractive force. The attractive force of a magnet being 150 lb. when free of disturbance, fell to one-half, by occasioning an armature to revolve near its poles. Therefore, when a system of magnets which had been constructed to produce a given power is set in revolution, every magnet at once suffers an immense loss of power, and consequently their combined action falls in practice very far short of their estimated power. This fact has not been before distinctly stated, although the author is informed that Jacobi observed it. And not merely does each magnet thus sustain an actual loss of power, but the power thus lost is converted into a new form of force, or rather becomes a current of electricity, acting in opposition to the primary current by which the magnetism is induced. From an examination of all these results, Mr. Hunt is disposed to regard electro-magnetic power as impracticable, on account of its cost, which must necessarily be, he conceives, under the best conditions, fifty times more expensive than steam power, and is at present at least 150 times as expensive.*

8. *Improvements in the Air-pump;* by Mr. VARLEY, Jr., (Athenæum.) —In place of the two barrels and vibrating intermittent motion of the ordinary pump, Mr. Varley has a continuous circular motion in the handle, and one double-acting barrel. The piston-rod is attached to a crank on the motion shaft, and the cylinder oscillates from its bottom, a packed joint being done away with by having the tube between the barrel and the receiver coiled spirally, which, by its spring, gives play enough for oscillation of the barrel. Mr. Varley explained his larger pump, in which there are some contrivances in addition to those already mentioned. Instead of a valve opening inwards into the barrel by the pressure of the air, as in the old pumps, the valve is worked by an eccentric, and is so arranged as to open a communication between

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* A new invention by Prof. Page, described at the recent meeting of the American Association, sets aside entirely this calculation; the whole expenditure for the zinc consumed in producing with his machine 1 horse power for 24 hours, is 20 cents.

the top and the bottom of the barrel at each stroke, by which the rarefaction of the air is doubled. He has obtained, with this pump, a vacuum of $\frac{1}{10}$ of an inch of mercury.

9. *On Photography on Glass;* by T. A. Malone, (Athenæum, No. 1179, p. 589.)—In repeating the experiment of M. Niepce de Saint-Victor on photography on albumen (published in the *Technologiste* for 1848,) I was led to devise a plan of my own for making "glass negatives." I proceeded as follows:—To the white of an egg its own bulk of water was added; the mixture beaten into a froth was then put into a strainer made of letter-paper so twisted as to form a cone, having a small aperture at its apex; pinned near the base to hold the paper to its shape. The clear diluted albumen soon passed through into a wide-mouthed bottle, which answered the double purpose of a receptacle for the fluid and a support to the cone. A piece of plate-glass, thick or thin, as you please, was then rubbed with a solution of caustic alkali, washed in water, and dried with a cloth: just before applying the albumen, the glass was breathed upon and rubbed with new blotting-paper; then, to remove dust and fibres, cotton wool was used. Unless this latter and every other precaution is taken to prevent dust, the picture will be full of spots produced by a greater absorption of iodine (in a subsequent process) in those than in the surrounding parts.

Now pour the albumen on the glass, inclining the plate from side to side until it is covered; allow the excess to run off at one of the corners, keeping the plate nearly vertical. As soon as the albumen ceases to drop rapidly, breathe on, or warm the lower half of the plate; the warmth and moisture of the breath will soon cause it to part with more of its albumen; wiping the edges constantly hastens the operation.

Until this plan was adopted, the coatings were seldom uniform; the upper half of the plate retained less albumen than the lower,—of course care must be taken to warm only the lower half. When no more albumen runs down, dry the plate. I use for this purpose a double-ring gas-burner of some eighty jets. A common fire answers as well, save now and then it imparts a little dust.

The film, when dry, is quite free from cracks, and is so thin and transparent that the brilliancy of the glass is unimpaired. It is almost necessary to mark it to know which side has been coated.

The next operation is to iodize the plate. Dilute pure iodine with dry white sand in a mortar, using about equal parts of each. Put this mixture into a square glass trough, and over it place the albumined plate; as soon as the latter has become yellow in color, resembling beautiful stained glass, remove it into a room lighted only by a candle, or through any yellow translucent substance—yellow calico, for instance. Here plunge it vertically and rapidly into a deep narrow vessel containing a solution of "aceto-nitrate" of silver, made by adding three ounces of nitrate of silver to two ounces of glacial acetic acid, diluted with sixty ounces of distilled water. Allow it to remain until the transparent yellow tint disappears, to be succeeded by a milky-looking film of iodid of silver. Washing with distilled water completes this operation. The plate is now ready for the camera. After it has been submitted to the action of the light pour over its surface a saturated solution of gallic acid. A negative Talbotype image on albumen is the result. Washing with water before and after immersion, in a solution of one part of hyposulphite of soda in 16 parts of water, until the yellow tint is removed from the shadows, completes the process.

But where is the novelty? Let us go back a step. While the gallic acid is developing its reddish-brown image, pour upon the surface a strong solution of nitrate of silver:—the brown image deepens in intensity until it becomes black. Another change commences: the image begins to grow lighter, and, by perfectly natural magic, finishes by converting the black into white, presenting the curious phenomenon of the conversion of a Talbotype *negative* into, apparently, a Daguerreotype *positive*, but by very opposite agency, no mercury being present;—metallic silver (probably) here producing the lights, while in the Daguerreotype it produces the shades of the picture. I have said probably, because it may be unwise to speculate chemically upon appearances which may depend solely on molecular arrangement:—an intricate subject, to which I hope this communication may prove a slight contribution.

Prof. Wheatstone has suggested to me the desirableness of substituting blackened wood or blackened ivory for glass plates; we should probably then have the novelty of a Daguerreotype on wood free from some of the disadvantages attendant on polished metal. Mr. Cundall suggests the application of it to wood blocks for wood engravers for certain purposes, making the drawings by light instead of by hand.

10. *Lead Statuary;* (Athenæum, No. 1176, p. 511.)—I doubt not every true lover of art will feel grateful to your Edinburgh correspondent for his excellent letter on the subject of the fitness of lead as an economical and most perfect substitute for bronze or other costly material for statuary and other sculptural works of art.

I trust the subject which he has brought before your readers will receive all due attention from those who practice, as well as from those who desire to encourage, this noble department of art.

The object which I have in view in intruding on your attention on this occasion is to confirm, as a practical man, the perfect fitness of lead as a substitute for all such works of art as have hitherto been executed in bronze or marble; and to add that, owing to the comparatively low temperature at which lead melts, and the ease and perfection with which it can be cast into the most intricate and delicate forms, our artists may resume that admirable system of casting groups of statuary and other complex sculptural designs which was in use during the finest periods of Greek and Italian art,—namely, by the employment of wax as the material for the original work, which yields such perfect facility for the execution—and when completed coating or enveloping the wax original in plaster of Paris, and then melting out the wax, and so leaving a most perfect mould, be the intricacy or complexity of the original ever so great. By this mode our artists may revel in the most difficult "undercutting," and be certain to bring forth a metal casting as sharp and perfect in all the integrity of its parts and minute details as was the original.

The addition of about five per cent. of *antimony* to the lead will give it not only great hardness, but enhance its capability to run into the most delicate details of the work. As to the durability of the lead for such works of art, any one who has observed the next to no waste which has taken place in lead exposed on the roofs of ancient buildings, will have in this way most abundant and satisfactory proof that it is in every sense of use as durable a material as bronze when subject simply to atmospheric action.

It would give me pleasure to enumerate several practical details in respect to the employment of lead for the purposes in question,—as also to detail the process of moulding hollow statues, &c.,—should you or any of your readers think such information worthy of your attention. I am, &c. JAMES NASMYTH.

11. *British Association.*—The British Association commenced its twentieth Meeting at Edinburgh on Wednesday, July 31. By Wednesday night 900 names had been recorded, and the receipts amounted to £814. At the first meeting, Wednesday night, Sir David Brewster, the President for the session, addressed the Association.

12. *Sun and Moon;* (L'Institut, No. 857.)—M. NIEPCE DE ST. VICTOR has obtained images of the sun and moon on beds of albumen rendered sensible by an accelerative process peculiar to it. These photographic experiments confirm the opinion before stated by MM. Fizeau and Foucault, that the centre of the sun gives out rays of a greater photogenic power than those of the sides.

13. *On a cloud of dust which obscured the sun for two days in Russia, on the 29th and 30th of April,* 1840, *during a clear sky and quiet weather;* by EHRENBERG, (Monatsb. Berlin Acad., Jan., 1850.)—This powder was furnished Ehrenberg by M. Eichwald. Microscopic examination brought to light 49 animal forms, soft portions of plants, a few crystals, a morpholite and some sand. This powder is distinguished from that of the trade winds by some prominent forms. Ehrenberg believes that there is reason for concluding that this meteoric powder is neither a terrestrial powder nor simple volcanic cinders.

14. *American Zoological Journal.*—We take pleasure in announcing the speedy appearance of a Zoological Journal at Cambridge (Massachusetts), under the direction and editorship of Prof. Agassiz. Zoologists will hail it with great pleasure, and all interested in science will be rejoiced that it is in hands so able. Its memoirs will bear upon whatever pertains to animal life, its development, anatomical structure, physiological relations, &c., and hence those who may find profit in its pages are numerous throughout this as well as other countries. It will mark the progress of this department of science over the world, and each number therefore will be laden with new truths from the most recent studies of animal life, at home and abroad. The editor is so well known for his own profound researches and original discoveries, that a word from us on this point would be superfluous.

15. *Discovery of the Antarctic Continent.*—This discovery, alluded to on page 137, was made in the winter of 1839–1840, in January, 1840, and not 1839. The French made their first discovery on the afternoon of the 19th of January, *three days* after the observation mentioned on the page referred to.

16. *Meeting of the American Association for the Advancement of Science at New Haven.*—This session commenced on the 19th of Au-

gust and was continued through the week with great zeal and interest. Prof. A. D. Bache, Superintendent of the U. S. Coast Survey, was president of the meeting. The number in attendance was larger than ever before, and the papers offered covered a wide range of subjects. The meeting was subdivided into three Sections—"General Physics and Mathematics"—"Geology and Natural History," and "Chemistry and Mineralogy." A general meeting was held for an hour morning and afternoon, and in the evening a session of a more popular character, at which time addresses and discussions were heard. Prof. Henry, Secretary of the Smithsonian Institute, and President of the Cambridge Meeting, delivered his address on Thursday evening. As this noble discourse will be published in full, it is unnecessary to say more than that it contained a most admirable review of ethics for science and was peculiarly fitted for the present period of scientific progress. The next *annual* meeting of the Association will be held at Albany on the 3d Monday of August, 1851, and the semi-annual meeting on the 1st Monday of May next, at Cincinnati. Prof. L. Agassiz is the President and Prof. W. B. Rogers, General Secretary, of the year. Prof. Spencer F. Baird, of the Smithsonian Institute, was appointed permanent Secretary, and charged with the publication of the proceedings and scientific correspondence. Professor Bache gave, as President of the Charleston Meeting, an interesting sketch of that session held in March last.

NATURAL HISTORY AND GEOLOGY.

On the position and character of the Reptilian Footprints in the Carboniferous Red Shale formation of Eastern Pennsylvania. By Prof. H. D. Rogers, Boston.

On the coal formation of the United States, and especially in Pennsylvania. By Prof. Henry D. Rogers.

On the connection of the deposits of common salt with climate. By Prof. Henry D. Rogers.

On the decomposition of Rocks and Minerals by water impregnated with carbonic acid. By Profs. W. B. Rogers, and H. D. Rogers.

Tertiary Fossils of Marshfield. By Dr. C. T. Jackson.

On ancient Pot-holes in Rocks. By Dr. C. T. Jackson.

The genus Amia, a true living representative of the old family of Cœlacanthi. By L. Agassiz, Harvard.

On the age of the metamorphic rocks of Eastern Massachusetts. By Prof. L. Agassiz.

Comparison between the young caterpillars of Lepidoptera and the adult Larvæ of Musquitoes, and on the mode of formation of Stigmata. By Prof. L. Agassiz.

Remarks upon the care which certain fishes take of their young. By Prof. L. Agassiz.

On the development of compound organs from single cells. By Prof. L. Agassiz.

Singular development of the liver, air-bladder and kidneys in Siluridæ. By Prof. L. Agassiz.

On the development of compound eyes in Articulata. By Prof. L. Agassiz.

On some points in the structure of Sclerodermes and Gymodonts. By Prof. L. Agassiz.

On the structure of the mouth in Crustacea. By Prof. L. Agassiz.

On the differences of Structure of Cells in Animals and corresponding differences in their functions. By Prof. L. Agassiz.

Comparison of the face of fishes with that of other Vertebrata and Man. By Professor L. Agassiz.

On the relation between coloration and structure in the higher animals. By Prof. L. Agassiz.

On the growth of the Egg, prior to the development of the embryo. By Prof. L. Agassiz.

On a new type of scales in Fishes. By Prof. L. Agassiz.

On a fossil species of Walrus found by Prof. Fraser on the shores of New Jersey. By Prof. L. Agassiz.

On the probable age of the Moa Bone Beds of New Zealand. By Reginald N. Mantell, C. E.

Notice of the discovery of a portion of the upper jaw of the Iguanodon with teeth in their natural position. By Reginald N. Mantell.

Relations of terrestrial Mollusca in Jamaica—gradation of species into each other. By Prof. C. B. Adams, Amherst College.

On the nature and origin of the species of terrestrial Mollusca, in the Island of Jamaica. By Prof. C. B. Adams.

Suggestion on changes of level in North America, during the drift period. By Prof. C. B. Adams.

On the value of Shells of Mollusca as furnishing distinctive characters. By Prof. C. B. Adams.

Curious growth of a Potato. By S. Webber.

Essay on the classification of Nemertes and Planariæ. By Charles Girard, Cambridge.

On a new Generic Type in the class of worms. By Chas. Girard.

On a new American Saurian Reptile. By Chas. Girard.

On the early uses of the metals as a medium of exchange. By J. H. Gibbon.

On the Volcanoes of central America, with observations on the Geographical and Topographical features of Nicaragua. By E. Geo. Squier.

Some observations on the gold formation of Maryland, Virginia and N. Carolina. By Prof. W. R. Johnson, Washington.

On the coal formation of Central North Carolina. By Prof. W. R. Johnson.

Researches on the origin, development, and nature of the spermatic particles throughout the Vertebrata. By Dr. W. J. Burnett, Boston.

On the Vibriona of Ehrenberg, not Animals, but Plants. By Dr. W. J. Burnett.

On Utricles as the primordial forms of all animal tissues. By Dr. W. J. Burnett.

On the relation of the distribution of Lice to the different Faunæ. By Dr. W. J. Burnett.

Notice of the habits of Ploiaria brevipennis. By Rev. Thomas Hill.

Notice of observations on drift Striæ in New Brunswick. By Prof. James Robb, Fredericton, N. B.

On the Taconic system. By T. S. Hunt, Montreal.

On some localities of Magnesite with remarks on its connection with the origin of Serpentine. By T. S. Hunt.

On the Cylindrical Structure observed in Potsdam Sandstone. By Franklin B. Hough, Somerville, N. Y. Read by Prof. C. U. Shepard.

Remarks on the Geology of Mackinac, Drummond of St. Joseph's Islands and the northern shores of Lake Michigan. By Prof. James Hall.

Remarks on the seventeen year Locust. By Miss Morris.

On the theories of the Deluge in reference to the Ethnographic distribution of the human race. By J. P. Lesley.

On the optical characters of American Micas. By Prof. B. Silliman, Jr.

On the origin of a curious spheroidal structure in certain sedimentary rocks. By Professor B. Silliman, Jr.

On the analogy between the mode of reproduction in plants and the alternating generations of some Radiata. By Prof. James D. Dana, Yale.

Description of the new genera of Plants found by Col. Fremont in California. By Dr. Torrey.

Fossil Coniferous Wood from the Devonian strata of Lebanon, Marion Co., Ky. By Prof. George C. Schaeffer. Read by Dr. W. J. Burnett.

PHYSICS AND MATHEMATICS.

On the origin and classification of Mechanical Powers. By Prof. Joseph Henry, Secretary of the Smithsonian Institution.

Analysis of the Dynamic Phenomena of the Leyden Jar. By Prof. Henry.

On the fundamental principles of Dynamics. By Prof. Benjamin Pierce, Harvard.

On the probable period of the fundamental star *α* Virginis. By Prof. B. Peirce.

On galvanic wave time. By R. Culmann, Bavaria.

Description of an instrument for exhibiting the mode of vibration in a molecule of unpolarized light. By Prof. E. S. Snell, Amherst.

On Lunar distances. By Prof. W. M. Chauvenet, of the U. S. Naval Academy.

Description of the Tidal observations at Cat Island in the Gulf of Mexico. By Prof. A. D. Bache, Superintendent U. S. Coast Survey.

On the modes adopted in the Coast Survey, for Charts of Currents. By Prof. A. D. Bache.

On the use in the Coast Survey, of the Zenith Telescope, by Talcott's method, and the discussion of the observations. By Prof. A. D. Bache.

On the late periodical visitation of the Aurora Borealis. By Prof. D. Olmsted.

Cause of the sudden disappearance of the ice of Lake Champlain. By Prof. D. Olmsted.

On certain points of electrical theory. By Prof. D. Olmsted.

On some peculiar properties of a compound of Lard and Rosin. By Prof. D. Olmsted.

Notice of a powerful Magnet. By Prof. B. Silliman, Jr.

On the optical moving of figures. By Prof Elias Loomis, New York University.

On electrical phenomena observed in certain houses. By Prof. Loomis.

On the continuance of the Magnetic and Meteorological Observations at the Toronto Observatory. By Prof. Loomis.

Some remarks on the theory of the solar spots. By Prof. H. D. Rogers, Boston.

On the theory of Storms. By Dr. Hare.

On the use of the zenith telescope in the determination of Latitude. By Prof. Lewis R. Gibbes, Charleston, S. C.

Description of a new instrument for measuring the angle contained between the optic axes of crystals, and for goniometrical purposes. Accompanied by the angles contained between the optic axes of some American Micas. By W. P. Blake, Yale Laboratory.

On the extension of Bode's Law. By Prof. Stephen Alexander, Princeton.

On the law of the induction of an electrical current upon itself. By Mr. J. H. Lane, Patent Office.

On a Whirlwind produced by the burning of a Cane-brake in Alabama. By Alexander Fisher Olmsted, New Haven.

On Monsoons on the shores of the North Atlantic. By Prof. J. H. Coffin.

On the apparent necessity for revising the received systems of Dynamical Meteorology. By W. C. Redfield, New York.

Communications on the Solar Eclipse of July, 1851. By Lieut. C. H. Davis, Supt. of the Nautical Almanac.

On the numerical computation of the co-efficients of the perturbatory function of Planetary motion. By Sears C. Walker.

On Barometrical measurements and the distance to which corresponding observations may be used for that purpose. By Prof. Arnold Guyot, Cambridge.

On a system of Meterological Observations established in the State of New York by order of the Regents of the University, in connection with, and according to the direction of, the Smithsonian Institute. By Prof. Arnold Guyot.

On the velocity of the galvanic Current in the Telegraph wires. By Dr. B. A. Gould, Jr.

On the Astronomical Journal. By Dr. B. A. Gould, Jr.

Method of ascertaining the velocity of the Galvanic current. By Orange Judd, Yale Analytical Laboratory.

Scientific interest of the proposed Industrial Exhibition at London in 1851. By W. R. Johnson.

On the influence of temperature on the absorption of light. By Prof. Wolcott Gibbs, New York.

On a mode of effecting the Achromatism of the Telescope by Lenses of the same dispersive power. By G. P. Bond, Harvard.

Notes on the progress of the determinations of the difference of Longitude between Greenwich and Cambridge, for the Coast Survey, by W. C. Bond, Director of Cambridge Observatory. By G. P. Bond, Cambridge.

On the variation in the proper motion of the fundamental star α Virginis. By Mr. E. Schubert of Cambridge.

On a new method of observing and recording astronomical R. A. and N. P. distances. By Prof. O. M. Mitchel, Cincinnati.

On the Laws of Perfect Musical Intonation, and their application to the Church Organ. By H. W. Poole.

A plan for stereotyping Catalogues of Libraries by separate titles, and for forming a general stereotype Catalogue of public Libraries of the United States. By C. C. Jewett, Assistant Sec. and Librarian of the Smithsonian Institute.

On the Nautical Almanac. By Charles H. Davis, Superintendent of the Nautical Almanac.

Elliptical Tables of the Planet Neptune. By Prof. George W. Coakley, St. James College, Maryland.

CHEMISTRY AND MINERALOGY.

Account of six new Mineral species. By Prof. Charles U. Shepard.

Notice of Foreign Meteorites and of a large stone lately found, of the Linn Co. fall, Missouri, Feb. 7, 1847. By Prof. C. U. Shepard.

Some notices of American Minerals. By Prof. Charles U. Shepard.

On the absorption of Carbonic Acid by acids and saline solutions. By Profs. W. B. Rogers and R. E. Rogers.

On a new method of decomposing silicates in the process of analysis, with an analysis of the Pink Scapolite of Bolton. By Henry Wurtz, New York.

On the availability of the Green Sand of New Jersey, as a source of potash and its compounds. By Henry Wurtz.

On the Troostite of New Jersey. By Henry Wurtz.

On Canadian localities of Ilmenite and Chromic Iron, with remarks upon the association of these minerals with the Gold of Canada and California. By T. S. Hunt, Canada Geol. Commission.

On the analysis of Soils and the ashes of Peat. By T. S. Hunt.

On the determination of Phosphoric Acid. By T. S. Hunt.

On a locality of Asphaltum and its origin. By T. S. Hunt.

On artificial Crystals of Sesquioxyd of Chromium (Ȼr,) with some observations on their formation. By W. P. Blake, Yale Laboratory.

On a new test for the nitrates. By G. C. Schaeffer, Prof. of Chemistry in Center College, Ky. Read, with comments, by T. S. Hunt.

On the assumed existence of Ammonia in the general atmosphere. By Aug. A. Hayes, M.D., Asssayer to the State of Massachusetts. Presented by Dr. C. T. Jackson.

Allanite of Franklin, N. J. By Dr. C. T. Jackson.

Telluret of Bismuth and Gold. By Dr. C. T. Jackson.

On the manufacture of Zinc and Zinc white. By Dr. C. T. Jackson.

Analysis of red marl of Springfield, Mass. By Dr. C. T. Jackson.

Zircon, Sodalite, Cancrinite, &c., Litchfield, Me. By Dr. C. T. Jackson.

Analyses relative to the economical value of Anthracite Coal Ashes. By Jonathan B. Bunce, Yale Laboratory.

On the relation of the chemical constitution of bodies to taste. By Prof. E. N. Horsford, Harvard.

On the connection between the chemical constitution of bodies and color. By Prof. E. N. Horsford.

On the Spheroidal State. By Prof. Horsford.

On the adulteration of Vermilion. By Henry Brown, Cambridge Laboratory.

Ammonia in Atmospheric Air. By Prof. E. N. Horsford.

Analysis of Phlogopite from St. Lawrence Co., New York. By Wm. J. Craw, Yale Laboratory.

Determinations of Nitrogen in two varieties of Indian Corn. By Wm. H. Brewer, Yale Laboratory.

Analysis of the ash of Sweet Corn. By Wm. H. Brewer.

An account of some experiments upon the cause of fermentation. By Dr. Henry Erni.

On American Spodumene. By George J. Brush.

On some peculiar properties of a compound of Lard and Rosin. By Prof. D. Olmsted, Yale College.

Notice of two American Meteoric Irons. By Prof. B. Silliman, Jr.

Proper height of Lightning Rods. By Prof. Elias Loomis, New York University.

On Rutile in Quartz and other Minerals. By Prof. O. P. Hubbard, Dartmouth College.

17. *Proceedings of the American Association for the Advancement of Science;* Third Meeting, held at Charleston, S. C., March, 1850. 216 pp. 8vo.—This volume made its appearance in time to greet the members of the Association at their recent meeting in August; and, considering the short interval since the adjournment at Charleston, the vote of thanks from the Association to the Secretary, Prof. Lewis R. Gibbes, for his superintendence of the work, was doubly due him. At this time we can mention only a list of the papers brought before that meeting.*

Catalogue of Plants inhabiting the vicinity of the Santee Canal, S. C. By H. W. Ravenel, Esq.

On the influence arising from the discovery of the Gulf Stream upon the Commerce of Charleston. By Lieut. M. F. Maury.

On the exudation of ice from the stems of Vegetables. By Prof. John LeConte.

Characteristics of the Hindoo Skull. By S. Kneeland, Jr.

On Meat Biscuit. By G. Borden, Jr.

Report of Committee on the communication of Lieut. Maury, upon Winds and Currents.

The Manatus not a Cetacean but a Pachyderm. By S. Kneeland, Jr.

A simple demonstration of the theorem, that the attraction of a sphere upon an exterior particle is the same as if the sphere were concentrated at its centre. By Prof. James H. Coffin.

On some of the applications of Natural Science to the moral laws of ancient nations. By Dr. J. H. Gibbon.

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* The asterisk where used below, signifies that an abstract of the memoir was not handed to the Secretary for publication in the Proceedings.

Results of observations on the direction and force of Wind at the Coast Survey Stations. By Prof. A. D. BACHE.

On the application of the Electro-Chronograph in determining the figure and density of the earth. By Lieut. M. F. MAURY.

Remarks on preceding paper by Prof. L. R. GIBBES; fitness of Stone Mountain, Ga., for such observations; smallest interval appreciable by the ear between the beats of two chronometers.

On the existence in some individuals of two Insensible spots on the Retina. By Prof. LEWIS R. GIBBES.

Researches on the generation and development of the Opossum. By Dr. MYDDELTON MICHEL.

Remarks of Prof. L. AGASSIZ on preceding paper; necessity of further details.

Remarks of Rev. Dr. BACHMAN on the same paper; vigor and power of suction of young opossum, just taken from the uterus.

On the Palæozoic Rocks of Alabama. By Prof. M. TUOMEY.*

On the peculiar sensations produced by a damp atmosphere. By Dr. W. L. JONES.

On the Fossil Equus. By Dr. ROBERT W. GIBBES.

Remarks on the preceding paper. By F. S. HOLMES. No fossil mammalian remains except cetacean, in the Eocene marl of So. Ca.

On the Northern Elephas, and on Mastodon angustidens. By Dr. R. W. GIBBES.

On Fossils common to several Formations. By Dr. R. W. GIBBES.

Remarks on the preceding paper by Prof. AGASSIZ and Prof. TUOMEY; the species common to two or more strata are very few.

On the air bladder of the Drum-fish, Pogonias fasciatus, and the mechanism by which the sound is produced. By Dr. J. E. HOLBROOK.*

Remarks on the preceding paper by Prof. AGASSIZ; development of air bladders.

Remarks on the paper of Prof. Tuomey, of yesterday, by Dr. E. RAVENEL and Lieut. MAURY; importance of the coal fields of Alabama to the navigation and commerce of the Pacific.

Remarks on the paper of Dr. R. W. Gibbes, of yesterday, by Prof. Agassiz; the species common to different formations are very few, mistakes in this respect are attributable to geological error.

Exhibition of a fossil reptile belonging to the genus Leiodon. By Prof. TUOMEY.

On the Currents of the Atlantic Ocean. By Lieut. M. F. MAURY.

Remarks on the preceding paper by Prof. AGASSIZ; or the fancied importance of the name of the first describer of a species.

On the Marine Flora of the Atlantic. By Prof. W. H. HARVEY.

On the comparative reflecting power of the Planets, Mars, Jupiter and Saturn. By Prof. LEWIS R. GIBBES.

Distribution of the Foraminifera on the Coast of New Jersey. By F. DE POURTALES.

Remarks on this paper, by Prof. AGASSIZ; the aid rendered to Naturalists, by the Coast Survey.

On the order of Succession of parts in Foraminifera. By F. DE POURTALES.

On the Principles of Classification in Zoology. By Prof. AGASSIZ.

On the American species of the genus Putorius. By the Rev. Dr. Bachman.*

On the alleged subsidence of the Coast of South Carolina. By Prof. Tuomey.*

Examination of the Physical History of the Jews, in its bearings on the question of the Unity of the Races. By Dr. J. C. Nott.

Remarks of Prof. Agassiz, after the reading of this paper; zoological evidence for the diversity of the Races.

Microscopic examination of the Pile of the Head of Albinos. By P. A. Browne, Esq.

On an easy mode of illustrating the difference in the Velocity of Sound in Gases. By Prof. Lewis R. Gibbes.

On the Morphology of the Medusæ. By Prof. Agassiz.

Recent Progress of the Telegraph Operations of the United States Coast Survey. By Prof. A. D. Bache.

On the General Circulation of the Atmosphere. By Lieut. M. F. Maury.

Measurement of the Base Line on Edisto Island, S. C. By Prof. A. D. Bache.

Account of three new American Meteorites, and geographical distribution of such bodies generally. By Prof. C. U. Shepard.

On the Structure of the Bones of Siren lacertina. By Dr. St. Julien Ravenel.*

On a new species of Menobranchus, from South Carolina. By Prof. Lewis R. Gibbes.

On the recent Squalidæ of the Coast of South Carolina, and Catalogue of the Recent and Fossil Echinoderms of South Carolina. By Dr. Edmund Ravenel.

On the Cretaceous Formation of Alabama, and the Artesian Wells in that State. By Prof. Tuomey.*

On the Resistance of Timber. By H. Haupt.

On the Carcinological Collections of the United States, and descriptions of new species. By Prof. Lewis R. Gibbes.

On the Morphological Differences of Organs. By Prof. L. Agassiz.*

Meteorological and Mortuary Chart of New Orleans, for 1849. By Dr. E. H. Barton.

Observations on the Geology of Ashley River, S. Carolina. By F. S. Holmes.

Remarks on the preceding paper, by Prof. Agassiz; the large number of Mammalia in the Fossil Beds of South Carolina.

Proximate Composition of parts of Flowers of Plants, and of the Plants themselves. By Dr. J. H. Salisbury.

On the Structure of the Halcyonoid Polypi. By Prof. Agassiz.

18. *Editorial note with reference to the article on the Electro-Chronograph, in Volume III.*—The article on the "Electro-Chronograph," which was published in this Journal for September of last year, contained allusions and imputations of an improper personal nature, reflecting discreditably upon the motives and veracity of some of the most eminent and unimpeachable among American laborers in science. We regret that these justly offensive portions escaped editorial notice at the time the article in question passed through the press. Our ob-

ject in alluding to the subject at this late day, (late because our attention was only recently called to it,) is, at once, to disavow on our own behalf all the expressions and passages of an offensive and personal nature which that article contains—to whomsoever they may apply—and at the same time to deprecate, in the most emphatic manner, all personalities in science, every instance of which we most earnestly desire to exclude from our pages. This statement we esteem in entire accordance with the limitation of editorial responsibility upon which we have uniformly acted, and which is fully expressed on page 151 of this volume.

OBITUARY.

19. M. DE BLAINVILLE.—At the funeral of M. de Blainville, which took place on Tuesday, the 7th of May last, a discourse was pronounced by M. Constant Prévost, another by M. Chevreul, and a third by M. Milne Edwards.—The following are some citations from the remarks of M. Prévost.

"But eight days since, on Tuesday last, at the same hour that now assembles us around this bier, I happened to be present at the last lecture of M. de Blainville. He was animated, full of his subject, and he entertained us for nearly an hour, exhibiting a freshness of ideas and facility of expression which bore no marks either of fatigue or apprehension. Some threatening symptoms had been experienced during the year past, but, with a force of character peculiar to him, he had sought to conceal them from all, and even from himself. Wednesday evening he proposed to visit his niece who was sick at Dieppe, intending to return in time for his lecture the following Saturday; but when about to start, he was found dead in the carriage where he had taken his seat but a few seconds before. * * * *

MARIE-HENRI DUCROTAY DE BLAINVILLE was born at Arques, September 12, 1778. A student of the military school of Beaumont near Touques, and destined, as a cadet of a noble family, to follow the career of arms, for some reason unknown to me he abruptly left the school in 1792. At the risk of his life he sought refuge on board a vessel cruising in the British channel and took part in several serious combats. Returning to France, M. de Blainville for some years of his youth, pursued with inconstant enthusiasm, an ardent imagination and an impetuous character, the study of different branches of literature and the arts. * * * *

At the age of twenty-seven (I believe) he was still undecided with regard to his future pursuits, when one day, as if by chance, or better, by the guidance of Providence, his vocation was irrevocably determined. He entered the college of France and heard a lecture by Cuvier. Struck at once with the interest of the subject and the eloquent words of the celebrated Professor, he left the building with the resolution to give himself to natural science and become a Professor. From this time his desultory habits were changed; in three years he went through courses of human anatomy and two years afterward (in 1810) he became a doctor of medicine. In 1812, having for some time assisted Cuvier at the College of France and at the Museum, he was appointed to the chair of Zoology, Anatomy and Physiology of the Faculty of Sciences; and in 1832, on the death of Cuvier, all eyes were upon M. de Blainville as the only person fitted to be his successor in the department of Comparative Anatomy. Thus 28 years from the period when his resolve was made had sufficed to place him, through his own efforts alone, in this supreme position in Science." * * * *.

20. CHRISTIAN VIII, KING OF DENMARK, (from the Anniv. Geol. Address of Sir C. Lyell, Quart. Jour. Geol. Assoc., No. 22, 1850.)—Christian VIII, King of Denmark was enrolled a Fellow of this Society in 1822. Two years before that time, when travelling in Italy, he had witnessed an eruption of Vesuvius, and had read a description of it to the Academy of Sciences at Naples; a communication published in their Transactions, and afterwards reprinted in Leonhard's Journal for 1822.

From an early age he had taken a lively interest in the progress of natural history, and when Crown Prince, formed at Copenhagen, at his own expense, a magnificent collection of shells, the number of species being estimated at not less than 12,000, exclusive of fossils. When I visited the Danish capital in 1835, he placed this museum and his library at my disposal, and I had then an opportunity of knowing that he kept up an acquaintance with the new species added from year to year to his cabinet, then in charge of an able conchologist, Dr. Beck, and that he was very desirous of making his museum useful to all zoologists. Nor was he inattentive to the points of controversy then agitated respecting the geology of Denmark. He questioned me closely as to my opinion, whether the strata of Faxoe, containing certain species of *Cyprea*, *Oliva*, *Mitra*, and other genera usually regarded as characteristic of the tertiary period, really belonged to that epoch, or to the cretaceous rocks. That the latter conclusion was correct I had satisfied myself, after exploring the cliffs of Moën and Seeland, as I have explained in your Transactions; and you are aware that the Faxoe beds, together with those of Maestricht and Sezanne near Paris, have been recently classed as an upper member of the great cretaceous system.*

When Christian VIII. succeeded to the throne, the cares and duties of an absolute monarch did not make him forgetful of his former love for natural history. He was always accessible to scientific foreigners and natives, and set on foot several publications, among which I may mention the 'Gæa Danica' of Professors Steenstrup and Forchhammer. He also gave his patronage to a splendid botanical work on the palms of Mexico, by Professor Liebmann, and promoted liberally the geological expedition of Baron von Waltershausen and Professor Bunsen to Iceland. He also took care that a good naturalist should accompany the voyage of the Galathea around the world; and when that expedition returned, he directed that the valuable collections, made by the officers in various countries, should be divided equally between the Universities of Copenhagen and Kiel. As Crown Prince, he had been elected President of the Academy of Sciences at Copenhagen, and when he attended their meetings, after his accession to the throne, he always declined to be received as king, taking his place simply as a member, or as any other President. After a reign of nine years, he died in January, 1848.

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* Geol. Trans., 2nd series, vol. v, p. 249.

21. **Darius Lapham.**—Mr. Lapham, at the time of his death (August of the present year), was Canal Collector at Cincinnati, and member of the State Board of Agriculture. He had charge of the preparation of the grounds for the State Fair, to be held in September.

In the death of Mr. Lapham the State Board of Agriculture has lost one of its most valuable members, and the State one of its best citizens. His death will be deplored by a very large circle of friends, to whom he was warmly attached for his many virtues, and modest, retiring deportment. It is but a few days ago that we received a letter from him, giving quite an encouraging account of the progress he was making in the extensive preparations for the State Agricultural Fair. To-day he is numbered with the dead.—*Ohio Statesman.*

22. Dr. **Troost.**—Gerard Troost, M.D., Professor of Chemistry, Geology and Mineralogy in the University of Nashville, after a protracted illness, departed this life on the 14th of August, at 1 o'clock, P. M.

Born and liberally educated in Holland, he early manifested a zealous devotion to Natural History and Chemistry, and more especially to the then infant sciences of Geology and Mineralogy. With a view to the more successful prosecution of his favorite studies, he visited Paris, and, for several years, was a pupil of the celebrated Haüy. He removed to the United States about forty years ago; and, in due time, became an American citizen. His entire life was consecrated to Geology and the kindred sciences. With what ability and success, his published writings and his well-earned reputation at home and abroad, may eloquently testify.

As a Professor in this University, during the last twenty-two years, and as the State Geologist of Tennessee for most part of that period, he won the confidence and respect of the community, by invaluable services in both capacities, as well as by the unaffected modesty, kindness, and uniform courtesy of his deportment towards all men. In the various stations and relations of life, public and private, he was without reproach and above suspicion. Beloved, trusted, honored, venerated, by all those most intimately connected or associated with him, he could not make an enemy—he had none.—(From the Proceedings of the Board of Trustees of the University of Nashville.)

V. BIBLIOGRAPHY.

1. *Tabulæ Atomicæ: Chemical Tables for the Calculation of Quantitative Analyses of H. Rose*, recalculated for the more recent determinations of atomic weights, and with other alterations and additions, by William P. Dexter. 70 pp. 8vo. Boston: Little & Brown. 1850.—The Tables of Atomic Weights by Rose are well known to chemists and fully appreciated. The author of this American edition has not simply given us a reprint of Rose. As the atomic weights of several of the elements have been changed through the recent investigations of chemists, a large amount of recalculations became necessary both in the numbers for the compounds of the elements whose atomic numbers have been redetermined, and for very many other elements whose equivalents were based on those that have been altered. To insure perfect accuracy, the calculations, as the author states, were performed by himself both directly and by logarithms;

and the columns of multiples were computed separately by himself and another. From the care thus taken, and the thorough knowledge which the author possesses, we may feel fully assured of the correctness of the work. Those atomic weights have been taken that were deemed most trustworthy, the determinations of Berzelius, being allowed, as by Rose, the greatest weight; some recent determinations have been rejected for want of confirmation. A column of logarithms has been added to the tables by Mr. Dexter. A large part of the compounds given in Rose's work under chlorine and sulphur have been omitted, as they were "of comparatively little practical use." The volume commences with an introduction of a dozen pages, consisting of observations on the numbers adopted, and their authorities. The author has verified the calculations from the chemical data furnished by different experimenters, and observes that in some cases he has detected a small error of computation. The number determined for titanium by Berzelius from Rose's analyses is 301·55, while it should be 301·304. In a similar manner the number for osmium was found to be 1243·624, instead of 1242·624; that of tungsten should be 1183·36, instead of 1188·36; that of phosphorus as computed by Berzelius is 392·041, while it should be 391·72. The tables are printed in a fair open type and are easy of reference.

2. *First Biennial Report on the Geology of Alabama;* by M. Tuomey, Geologist of the State; Professor of Geology, etc., in the University of Alabama, 176 pp. 8vo. Tuscaloosa, 1850. M. D. J. Slade. —Prof. Tuomey presents in this Report the results of a general reconnoissance of the State, mentioning its great geological features and its resources, in order to show what is required for future explorations and the importance which attaches to the survey. The results obtained exhibit the state as rich in various mineral products as well as in facts of geological interest, and we shall look for much profit and instruction from its full survey by one so capable and so exact in observation. The following facts are from this first biennial Report.

Metamorphic Rocks enter Alabama from the upper corner of Carroll county; their northwest boundary passes through the southeast corner of Benton county, thence southwesterly three or four miles east of the town of Talladega, and crossing the Coosa above Fort Williams, it runs through the lower corner of Antauga county. The part of the state east of this line is wholly covered by these rocks. In the bed of the Coosa they are laid bare as low as Wetumpka, which, as observed by McClure, is the most southern exposure of this important group of rocks in the United States. The gold-bearing rocks extend from Randolph to Antauga. A white and gray marble is quarried near Talladega creek and worked for ornamental purposes. Some of the pure white is of fine quality, little inferior to the Italian, and blocks thirty inches in thickness may be procured.

A Silurian limestone is seen at Centreville on the Catawba, which forms the southern extremity of the Silurian System of Alabama, and probably of the United States. To the east, Silurian rocks spread out towards the Coosa in Antauga and Shelby, until they cover the metamorphic rocks in Talladega, Benton and Cherokee counties. Along the Coosa they make their appearance on the east, coming out from under the Carboniferous rocks of the Cahawba Valley, and higher up in the same manner at the Lookout Mountain, whence they extend to Rome in Georgia. Sixteen miles southeast of Tuscaloosa they are visible, and thence they stretch north to the head of Murphree's Valley, separating the Warrior coal field on the west from that of the Cahawba on the east; and in this direction they are confined to a series of continuous valleys. They constitute a range of hills known as the "Red Mountains," so called from the presence of a bed of red oxyd of iron. Other small patches are mentioned, and further explorations will probbly enlarge this extent of Silurian beds. The red iron ore consists of grains mostly flattened, like the lenticular argillaceous ore of New York. In some places it passes into a conglomerate containing siliceous pebbles. A bed of brown hematite occurs on Shultz Creek, also near the headwaters of Hurricane and Rockcastle Creeks twenty-four miles from Tuscaloosa, and at Bucksville.

Heavy spar occurs in a vein a foot or two thick, near Pratt's Ferry on the Cahawba, and in another similar above Elyton. It is ground up for white paint.

The carboniferous rocks cover all that part of the state above the lower falls of the rivers, not already described as belonging to the Red Mountain group. The greatest development of the calcareous beds enters Alabama as a prolongation of the Cumberland Mountains. Caves abound in these rocks, and the earth frequently contains nitrates, from which nitrate of potash is obtained. The coal measures every where rest on millstone grit. The mountains of Madison and Jackson counties and the hills of Morgan and Marshall counties are often capped with sandstones and shales containing beds of coal. The Raccoon and Lookout Mountains have coal beds of considerable extent. These connect with the measures of the Locust Fork of Warrior creek, and the Cahawba, while the isolated patches of the hills in Morgan and Lawrence run into those of the Sipsey and Mulberry Forks, in such a manner as to leave no doubt of their being parts of one continuous and vast coal field. The St. Clair coal field on the Coosa, connected with the Cahawba on the southwest contains about 150 square miles. The Cahawba coal field is bounded on the south and east by the Little Cahawba and its tributary, Shoal Creek, on the east by Shades Creek as low as Bucksville, and reaches within two miles of Montevallo and within three miles of the river at Lacy's Ferry. It contains 180 to 200 square miles. The Warrior coal field occupies the region drained by the Warrior river and its tributaries, covering for the most part the counties of Walker, Blount, Jefferson and Tuscaloosa, and having an area of about 5000 square miles. The carboniferous rocks of DeKalb, Morgan and Lawrence counties have not yet been explored. The Tuscaloosa coal has been long in use in the state.

The Report continues with observations on the cretaceous and tertiary rocks.

3. *A Treatise of Plane and Spherical Trigonometry*; by William Chauvenet, A.M., Professor of Mathematics in the United States Naval Academy. pp. 256, 8vo. Philadelphia: Henry Perkins. 1850.—In this treatise, the author as he states in the preface, has undertaken "to arrange a course of trigonometrical study sufficiently extensive to enable the student to comprehend readily any applications of trigonometry he may meet with in the works of the best modern mathema-

ticians." For this purpose it was necessary to extend the treatise much beyond the ordinary limits of the elementary text-books used in academies and colleges. But the author has sought to adapt his work for the use of College classes, by putting the elementary matter in larger type, so that it may easily be read independently of the other portion of the book. A complete and well arranged treatise of trigonometry has been greatly needed for the use of mathematical teachers, and of practical astronomers, surveyors, engineers, &c. No work of this kind has before been published in this country; and we know of no English work in which the subject of spherical trigonometry especially, is presented in a satisfactory manner. Many useful formulæ now commonly employed in astronomical investigations are not to be found in the larger and more recent treatises of trigonometry published in England. These deficiencies are well supplied in the work of Mr. Chauvenet: and from the examination we have been able to make we are satisfied that it will prove a more convenient and useful manual for the mathematical teacher and the practical mathematician than any similar English or American work. It would perhaps have been somewhat better for purposes of reference, if the author had added tables in the customary way, giving a synoptical view of the more useful trigonometric formulæ.

4. *A descriptive account of the Freshwater Sponges of the Island of Bombay with observations on their structure and development;* by H. J. Carter, Esq., Assistant Surgeon, Bombay Establishment, 22 pages, 8vo, with 3 plates, (from the Jour. Bombay Branch of the Roy. Asiat. Soc., No. xii, 1849.)—The author in this paper describes 5 species of Spongilla—the S. cinerea, alba, Meyeni, plumosa, new, and the S. friabilis? of Lamarck. With regard to them he observes that in each species excepting the *cinerea* they cannot be said to be characterized by any particular form. The memoir contains interesting details respecting the structure and development of the sponge, many of which are exceedingly curious. The memoir is illustrated by good engravings showing well the structure and the varying forms of the sponge cell.

We cite the following observations on the sponge cell, which are exposed on tearing a newly formed sponge, and the protean cells developed from the contents of the seed-like bodies when forcibly expelled.

"The sponge-cell when *in situ*, is ever changing its form, both partially and wholly; its granules also are ever varying their position with, or independently of the movements of the cell, and its pellucid vesicle or vesicles, dilating and contracting themselves or remaining passively distended, and exhibiting in their interior molecules of extreme minuteness in rapid commotion. When first separated from the common mass, this cell for a short time assumes a globular form and afterwards, in addition to becoming polymorphic, evinces a power of locomotion. During its polymorphism it emits expansions of its cell-wall in the form of obtuse or globular projections, or digital and tentacular prolongations. If in progression it meets with another cell, both combine, and if more are in the immediate neighborhood, they all unite together into one common globular mass. Should a spiculum chance to be in the course of a cell, it will ascend it and traverse it from end to end, subsequently quitting it or assuming a globular form, embrace some part of it and remain stationarily attached to it. The changes in shape and position of the sponge-cell and its intercellular mucilage are for the most part effected so imperceptibly, that they may be likened to those which take place in a cloud. Its granules however are more active, but there appears to be no motion in any part of the cell, excepting among the molecules within the hyaline vesicle, which in any way approaches to that characteristic of the presence of cilia.

"It should be understood however, that these remarks are not applicable to every sponge-cell, although fully developed, which appears in the field of the microscope, but they are rather a statement of what a sponge cell may evince, than of what every sponge-cell does evince.

"The polymorphic cells or proteans which appear in the watch-glass after the contents of a seedlike body have been forcibly expelled into it under distilled water, are much more active in their movements. Their cell-walls frequently assume the most fantastic figures, spheroidal, polygonal, asteroid, dendritic, &c. Their green granules move backwards or forwards, to this side or to that with great activity, as the part of the cell to which they are attached is entrained in one direction or another; while their hyaline vesicle or vesicles (in progression) appear occasionally in every part, not only of the body of the cell, but in its tubular prolongations. The contraction of the hyaline vesicle seems to take place most frequently when it arrives at the posterior extremity, that is according to the direction in which the cell is progressing; next in frequency, at the sides, seldom in the anterior or central part of the mass. When contraction takes place, it is effected more or less completely, more or less suddenly; if complete, a dark speck or opacity marks the original position of the vesicle, in the centre of which, if watched, it may be observed to re-appear, and as it is carried forward in the movements of the cell with the portion to which it is attached, it gradually regains its original size, and returning in due course to the point from which it started, again contracts as before.

"In progression, some of the large proteans developed in the way just mentioned appear to be conscious of the nature of certain objects which they encounter in their course, since they will stop and surround them in their cell-wall. It is not uncommon to see a portion of a spiculum in the latter position, the larger germs of the sponge itself, the body of a loricated animalcule the 900th part of an inch in diameter, on which the pressure exerted by the protean may be seen by the irregular form assumed by the animalcule the moment it has become surrounded. I once saw one of these proteans approach a gelatinous body, something like a sluggish or dead one of its own kind, and equal to itself in size, and having lengthened itself out so as to encircle it, send processes over and under it from both sides, which uniting with each other, at last ended in a complete approximation of the two opposite folds of the cell-wall, throughout their whole extent, and in the enclosure of the object within the duplicature. Even while the protean was thus spreading out its substance into a mere film, to surround so large an object, a tubular prolongation was sent out by it in another direction to seize and enclose in the same way, a large germ which was lying near it. After having secured both objects, the protean pursued its course, rather more slowly than before, but still shooting out its dentiform processes with much activity. It took about three quarters of an hour to perform these two acts."

5. *Recherches Anatomiques et Zoologiques faites pendant un Voyage sur les cotes de la Sicile et sur divers points du littoral de la France;* par MM. MILNE EDWARDS, A. DE QUATREFAGES and EMILE BLANCHARD. 3 volumes, 4to, with numerous plates.—These volumes consist of a series of memoirs on the structure, development and physiology of various animals in different departments of zoology. They are the result of investigations of the most minute microscopic character pursued by the first zoologists of France; the observations are profound, and exact, and the illustrations unsurpassed for fullness and beauty. The *First* volume, by MILNE EDWARDS, contains memoirs on the development of Annelids, on the classification of the Gasteropodous Molluscs, and on the general subject of circulation; the *Second* by M. DE QUATREFAGES, treats of the nervous system and History of the Amphioxus, of the Pycnogonidæ, Phlebenterisma, Planariæ, the Nemertes, Echiurus Gærtnerii, with a review of the observations made in 1844 on the Gasteropoda Phlebenterata; the *third* by M. BLANCHARD, is occupied with a memoir of 336 pages on the organization of Vermes, especially the subdivision "Entomozoaires apodes" of Blainville. Many of these memoirs have appeared in some of the later volumes of the Annales des Sciences Naturelles.

6. *Les Alpes, Journal des Sciences Naturelles, Agricoles, Medicales, Physiques et Astronomiques*, contenant un résumé de tous les travaux qui concernent la Suisse et la Savoie et de tous ceux qui sont publiés dans ces deux pays.—Issued in a sheet of 8 quarto pages, on the 1st and 15th of each month. This periodical made its first appearance on the 1st of July last. It is edited by *Gabriel Mortillet* ingénieur civil à Genève, place de la Fusterie, 78 au 2me. The subscription price for foreigners is 12 francs a year. The object of this Journal is to give a brief review of all new scientific matters relating to Switzerland and Savoy and also of whatever may be published in these countries.

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A. D'ORBIGNY: Prodromus de Palæontologie Stratigraphique Universelle. 3 vols. 8vo. *Paris.* 24*fr.* Volume 1 is on sale for 8 francs.

LIEUT. M. L. SMITH and CAPT. E. L. F. HARDCASTLE: Map of the Valley of Mexico with a plan of the defences of the Capital and the line of operations of the U. S. Army under Major General Scott, in August and September, 1847. Surveyed and drawn by Lt. M. L. Smith and Brevt. Capt. E. L. F. Hardcastle, U. S. Top. Engineers, (Senate U. S., Ex. Doc. No. 11.)

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[SECOND SERIES.]

Art. XXIV.—*Address of Sir David Brewster before the Twentieth Meeting of the British Association at Edinburgh, July* 31, 1850.*

* * * It has been the custom of some of my predecessors in this chair to give a brief account of the progress of the sciences during the preceding year; but however interesting such a narrative might be, it would be beyond the power of any individual to do justice to so extensive a theme, even if your time would permit and your patience endure it. I shall make no apology, however, for calling your attention to a few of those topics, within my own narrow sphere of study, which, from their prominence and general interest, may be entitled to your attention. I begin with Astronomy, a study which has made great progress under the patronage of this Association—a subject, too, possessing a charm above all other subjects, and more connected than any other with the deepest interests, past, present, and to come, of every rational being. It is upon a planet that we live and breathe. Its surface is the arena of our contentions, our pleasures, and our sorrows. It is to obtain a portion of its alluvial crust that man wastes the flower of his days, and prostrates the energies of his mind, and risks the happiness of his soul; and it is over or beneath its verdant turf that his ashes are to be scattered or his bones to be laid. It is from the interior too—from the inner life of the earth that man derives the materials of civilization—his coal, his iron, and his gold. And deeper still, as geologists have proved—and none

with more power than the geologists around me—we find in the bosom of the earth written on blocks of marble—the history of primæval times, of worlds of life created, and worlds of life destroyed. We find there, in hieroglyphics as intelligible as those which Major Rawlinson has deciphered on the slabs of Nineveh, the remains of forests which waved in luxuriance over its plains—the very bones of huge reptiles that took shelter under their foliage, and of gigantic quadrupeds that trod uncontrolled its plains, the law-givers and the executioners of that mysterious community with which it pleased the Almighty to people his infant world. But though man is but a recent occupant of the earth, an upstart in the vast chronology of animal life, his interest in the Paradise so carefully prepared for him is not less exciting and profound. For him it was made, he was to be the lord of the new creation, and to him it especially belongs to investigate the wonders it displays and to learn the lesson which it reads. But while our interests are thus closely connected with the surface and the interior of the earth, interests of a higher kind are associated with it as a body of the solar system to which we belong.

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* From the Athenæum, No. 1188.

The object of Geology is to unfold the history and explain the structure of a planet; and that history and that structure may, within certain limits, be the history and the structure of all the other planets of the system—perhaps of all the other planets of the universe. The laws of matter must be the same wherever matter is found. The heat which warms our globe radiates upon the most distant of the planets, and the light which twinkles in the remotest star is, in its physical, and doubtless in its chemical properties, the same that cheers and enlivens our own system; and if men of ordinary capacity possessed that knowledge which is within their reach, and had that faith in science which its truths inspire, they would see in every planet around them, and in every star above them, the home of immortal natures—of beings that suffer and of beings that rejoice—of souls that are saved and of souls that are lost. Geology is, therefore, the first chapter of astronomy. It describes that portion of the solar system which is nearest and dearest to us,—the cosmopolitan observatory, so to speak, from which the astronomer is to survey the sidereal universe, where revolving worlds and systems of worlds summon him to investigate and adore. There, too, he obtains the great base lines of the earth's radius to measure the distances and magnitudes of the starry host, and thus to penetrate by the force of *reason* into those infinitely distant regions where the imagination dare not follow him. But Astronomy, though thus sprung from the earth, seeks and finds, like Astræa, a more congenial sphere above. Whatever cheers and enlivens our terrestrial paradise is derived from the orbs around us. Without the light or heat of our sun, and without the uniform movements of our system, we should have neither climates nor seasons. Darkness would blind, and famine destroy, everything that lives. Without influences from above, our ships would drift upon the ocean, the sport of wind and wave, and would have less security for reaching their destination than balloons floating in the air and subject to the caprice of the elements. But while the study of Astronomy is essential to the very existence of social life, it is instinct with moral influences of the highest order. In the study of our own globe we learn that it has been rent and upheaved by tremendous forces—here sinking into ocean depths, and there rising into gigantic elevations. Even now, geologists are measuring the rise and fall of its elastic crust; and men who have no faith in science often learn the truth to their cost, when they see the liquid fire rushing upon them from the volcano, or stand above the yawning crevice in which the earthquake threatens to overwhelm them. Who can say that there is a limit to agencies like these? Who could dare to assert that they may not concentrate their yet divided energies, and rend in pieces the planet which imprisons them? Within the bounds of our own system, and in the vicinity of our own Earth, between the orbits of Mars and Jupiter, there is a wide space which, according to the law of planetary distances, ought to contain a planet. Kepler predicted that a planet would be found there—and strange to say, the astronomers of our own times discovered at the beginning of the present century four small planets, Ceres, Pallas, Juno and Vesta, occupying the very place in our system where the anticipated planet ought to have been found. Ceres, the first of these, was discovered by Piazzi, at Palermo, in 1801; Pallas, the second of them, by Dr. Olbers, of Bremen, in 1802; Juno, the third, by Mr. Harding, in 1804; and Vesta, the fourth, by Dr. Olbers, in 1807. After the discovery of the third, Dr. Olbers suggested the idea that they were the fragments of a planet that had been burst in pieces; and considering that they must all have diverged from one point in the original orbit, and ought to return to the opposite point, he examined these parts of the heavens, and thus discovered the planet Vesta. But though this principle was in the possession of astronomers, nearly forty years elapsed before any other planetary fragment was discovered. At last, in 1845, Mr. Hencke, of Driessen, in Prussia, discovered the fragment called Astræa, and, in 1847, another, called Hebe. In the same year our countryman, Mr. Hind, discovered other two, Iris and Flora. In 1848 Mr. Graham, an Irish astronomer, discovered a ninth fragment called Metis. In 1849 Mr. Gasparis, of Naples, discovered another, which he calls Hygeia; and within the last two months, the same astronomer has discovered the eleventh fragment, to which he has given the name of Parthenope.[*] If these eleven small planets are really the remains of a larger one, the size of the original planet must have been considerable. What its size was, would seem to be a problem beyond the grasp of reason. But human genius has been permitted to triumph over greater difficulties. The planet Neptune was discovered before a ray of its light had entered the human eye; and by a law of the solar system just discovered, we can determine the original magnitude of the broken planet long after it has been shivered into fragments,—and we might have determined it even after a single fragment had proved its existence. This law we owe to Mr. Daniel Kirkwood, of Pottsville, a humble American, who, like the illustrious Kepler, struggled to find something new among the arithmetical relations of the planetary elements. Between every two adjacent planets there is a point where their attractions are equal. If we call the distance of this point on one side of a planet to that on the other, the *diameter* of its sphere of attraction, then Mr. Kirkwood's law is, that in every planet the square of the length of its year, reckoned in days, varies as the cube of the diameter of its sphere of attraction. This law has been verified by more than one American astronomer, and there can be no doubt, as one of them expresses it, that it is at least a physical fact in the mechanism of our system. This law requires the existence of a planet between Mars and Jupiter; and it follows from the law that the broken planet must have been a little larger than Mars, or about 5,000 miles in diameter, and that the length of its day must have been about 57½ hours. The American astronomers regard this law as amuonting to a demonstration of the nebular hypothesis of Laplace; but we venture to say that this opinion will not be adopted by the astronomers of England. Among the more recent discoveries within the bounds of our own system, I cannot omit to mention those of our distinguished countryman, Mr. Lassels, of Liverpool. By means of a fine twenty-feet reflector, constructed by himself, he detected the satellite of Neptune, and more recently an eighth satellite circulating round Saturn—a discovery which was made on the very same day, by Mr. Bond, Director of the Observatory of Cambridge, in the United States.

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[*] Ceres	1801, January 1	Piazzi.
Pallas	1802, March 28	Olbers.
Juno	1804, September 1	Harding.
Vesta	1807, March 29	Olbers.
Astræa	1845, December 8	Hencke.
Hebe	1847, July 1	Hencke.
Iris	1847, August 13	Hind.
Flora	1847, October 18	Hind.
Metis	1848, April 25	Graham.
Hygeia	1849, April 12	Gasparis.
Parthenope	1850, May 11	Gasparis.

Mr. Lassels has still more recently, and under a singularly favorable state of the atmosphere, observed the very minute, but extremely black, shadow of the ring of Saturn upon the body of the planet. He observed the line of shadow to be notched, as it were, and almost broken up into a line of dots; thus indicating mountains upon the plane of the ring—mountains doubtless raised by the same internal forces and answering the same ends as those of our own globe. In passing from our solar system to the frontier of the sidereal universe around us, we traverse a gulf of inconceivable extent. If we represent the radius of the solar system, or of Neptune's orbit (which is 2,900 millions of miles) by a line two miles long, the interval between our system, or the orbit of Neptune, and the nearest fixed star will be greater than the whole circumference of our globe—or equal to a length of 27,600 miles. The parallax of the nearest fixed star being supposed to be one second, its distance from the sun will be nearly 412,370 times the radius of the earth's orbit, or 13,746 times that of Neptune, which is thirty times as far from the sun as the earth. And yet to that distant zone has the genius of man traced the Creator's arm working the wonders of his power, and diffusing the gifts of his love—the heat and the light of suns—the necessary elements of physical and intellectual life. It is by means of the gigantic telescope of Lord Rosse that we have become acquainted with the form and character of those great assemblages of stars which compose the sidereal universe. Drawings and descriptions of the more remarkable of these nebulæ, as resolved by this noble instrument, were communicated by Dr. Robinson to the last meeting of the Association; and it is with peculiar satisfaction that I am able to state that many important discoveries have been made by Lord Rosse and his assistant, Mr. Stoney, during the last year. In many of the nebulæ the peculiarities of structure are very remarkable, and, as Lord Rosse observes, "seem even to indicate the presence of dynamical laws almost within our grasp." The spiral arrangement so strongly developed in some of the nebulæ is traceable more or less distinctly in many; but "more frequently," to use Lord Rosse's own words, "there is a nearer approach to a kind of irregular, interrupted, annular disposition of the luminous material, than to the regularity observed in others; but his Lordship is of opinion that those nebulæ are systems of a very similar nature, seen more or less perfectly, and variously placed with reference to the line of sight. In re-examining the more remarkable of these objects, Lord Rosse intends to view them with the full light of his six feet speculum, undiminished by the second reflexion of the small mirror. By thus adopting what is called the *front view*, he will doubtless, as he himself expects, discover many new features in those interesting objects. It is to the influence of Lord Rosse's example that we are indebted for the fine Reflecting Telescope of Mr. Lassels, of which I have already spoken; and it is to it, also, that we owe another telescope, which, though yet unknown to science, I am bound in this place especially to notice. I allude to the reflector recently constructed by Mr. James Nasmyth, a native of this city, already distinguished by his mechanical inventions, and one of a family well known to us all, and occupying a high place among the artists of Scotland. This instrument has its great speculum twenty feet in focal length, and twenty inches in diameter; but it differs from all other telescopes in the remarkable facility with which it can be used. Its tube moves vertically upon hollow trunnions, through which the astronomer, seated in a little observatory, with only a horizontal motion, can view at his ease every part of the heavens. Hitherto, the astronomer has been obliged to seat himself at the upper end of his Newtonian telescope; and if no other observer will acknowledge the awkwardness and insecurity of his position, I can myself vouch for its danger, having fallen from the very top of Mr. Ramage's twenty-feet telescope when it was directed to a point not far from the zenith.

Though but slightly connected with astronomy, I cannot omit calling your attention to the great improvements—I may call them discoveries—which have been recently made in *Photography*. I need not inform this meeting that the art of taking photographic *negative* pictures upon paper was the invention of Mr. Fox Talbot, a distinguished member of this Association. The superiority of the Talbotype to the Daguerreotype is well known. In the latter the pictures are reverted, and incapable of being multiplied; while in the Talbotype there is no reversion, and a single negative will supply a thousand copies, so that books may now be illustrated with pictures drawn by the sun. The difficulty of procuring good paper for the negative is so great, that a better material has been eagerly sought for; and M. Niepce, an accomplished officer in the French service, has successfully substituted for paper a film of albumen, or the white of an egg, spread upon glass. This new process has been brought to such perfection in this city by Messrs. Ross & Thompson, that Talbotypes taken by them and lately exhibited by myself to the National Institute of France, and to M. Niepce, were universally regarded as the finest that had yet been executed. Another process, in which gelatine is substituted for albumen, has been invented, and successfully practised by M. Poitevin, a French officer of engineers; and by an ingenious method which has been minutely described in the weekly proceedings of the Institute of France, M. Edmund Becquerel has succeeded in transferring to a daguerreotype plate the prismatic spectrum, with all its brilliant colors, and also though in an inferior degree, the colors of the landscape. These colors, however, are very fugaceous: yet, though no method of fixing them has hitherto been discovered, we cannot doubt that the difficulty will be surmounted, and that we shall yet see all the colors of the natural world transferred by their own rays to surfaces both of silver and paper. But the most important fact in photography which I have now to mention, is the singular acceleration of the process discovered by M. Niepce, which enables him to take the picture of a landscape illuminated by diffused light, in a single second, or at most in two seconds. By this process he obtained a picture of the sun on albumen so instantaneously, as to confirm the remarkable discovery previously made by M. Arago, by means of a silver plate, that the rays which proceed from the central parts of the sun's disc have a higher photogenic action than those which issue from its margin. This interesting discovery of M. Arago is one of a series on photometry which that distinguished philosopher is now occupied in publishing. Threatened with a calamity which the civilized world will deplore—the loss of that sight which has detected so many brilliant phenomena and penetrated so deeply into the mysteries of the material world, he is now completing, with the aid of other eyes than his own, those splendid researches which will immortalize his own name and add to the scientific glory of his country.

From these brief notices of the progress of science I must now call your attention to two important objects with which the British Association has been occupied since their last meeting. It has been long known both from theory and in practice, that the imperfect transparency of the earth's atmosphere, and the unequal refraction which arises from differences of temperature combine to set a limit to the use of high magnifying powers in our telescopes. Hitherto, however, the application of such high powers was checked by the imperfections of the instruments themselves; and it is only since the construction of Lord Rosse's telescope that astronomers have found that, in our damp and variable climate, it is only during a few days of the year that telescopes of such magnitude can use successfully the high magnifying powers which they are capable of bearing. Even in a cloudless sky, when the stars are sparkling in the firmament, the astronomer is baffled by influences which are invisible; and while new planets and new satellites are being discovered by instruments comparatively small, the gigantic Polyphemus lies slumbering in his cave, blinded by thermal currents more irresistible than the firebrand of Ulysses. As the astronomer, however, cannot command a tempest to clear his atmosphere nor a thunder-storm to purify it, his only alternative is to remove his telescope to some southern climate, where no clouds disturb the serenity of the firmament, and no changes of temperature distract the emanations of the stars. A fact has been recently mentioned, which entitles us to anticipate great results from such a measure. The Marquess of Ormonde is said to have seen from Mount Etna, with his naked eye, the satellites of Jupiter. If this be true, what discoveries may we not expect, even in Europe, from a large reflector working above the grosser strata of our atmosphere? This noble experiment of sending a large reflector to a southern climate has been but once made in the history of science. Sir John Herschel transported his telescopes and his family to the south of Africa, and during a voluntary exile of four years' duration he enriched astronomy with many splendid discoveries. Such a sacrifice, however, is not likely to be made again; and we must, therefore, look to the aid of government for the realization of a project which every civilized people will applaud, and which, by adding to the conquests of science, will add to the glory of our country. At the Birmingham meeting of the Association, their attention was called to this subject; and being convinced that great advantages would accrue to science from the active use of a large reflecting telescope in the southern hemisphere, they resolved to petition government for a grant of money for that purpose. The Royal Society readily agreed to second this application; and as no request from this Association has ever been refused, whatever government was in power, we have every reason to expect a favorable answer to a memorial from the pen of Dr. Robinson, which has just been submitted to the Minister. A recent and noble act of liberality to science on the part of the government justifies this expectation. It is, I believe, not yet generally known that Lord John Russell has granted 1,000*l.* a year to the Royal Society for promoting scientific objects. The Council of that distinguished body has been very solicitous to make this grant effective in promoting scientific objects, and I am persuaded that the measures they have adopted are well fitted to justify the liberality of the government. One of the most important of these has been to place 100*l.* at the disposal of the committee of the Kew Observatory. This establishment, which has for several years been supported by the British Association, was given to us by the Government as a depository for our books and instruments and as a locality well fitted for carrying on electrical, magnetical and meteorological observations. During the last six years the Observatory has been under the honorary superintendence of Mr. Ronalds, who is well known to the scientific world for his ingenious photographic methods of constructing self-registering magnetical and meteorological apparatus. On the joint application of the Marquess of Northampton and Sir John Herschel, Her Majesty's government have granted to Mr. Ronalds a pecuniary recompense of 250*l.* for these inventions; and I am glad to be able to state that Mr. Brooke has also received from them a suitable reward for inventions of a similar kind. Under the fostering care of the

British Association the most valuable electrical observations have been made at Kew, and Mr. Ronalds has continued from year to year to make those improvements upon his apparatus which experience never fails to suggest. But I regret to say, that in consequence of our diminished resources, the Association, at its meeting in 1848, came to the resolution of discontinuing the observations at Kew, appropriating at the same time an adequate sum for completing those which were in progress, and for reducing and discussing the five years' electrical observations which had been published in our Annual Reports. I trust, however, that means will yet be found to maintain the Observatory in full activity, and carry out the original objects contemplated by the Committee. Having had an opportunity of visiting this establishment this summer, after having inspected two of the best conducted observatories on the Continent where the same class of observations are made, I have no hesitation in speaking in the highest terms of the value of Mr. Ronalds's labors, and in recommending the institution which he so liberally superintends to the continued protection of the Association and the continued liberality of the Royal Society. From the facts which I have already mentioned, and from many others to which I might have referred, the members of the Association will observe, with no common pleasure, that the Government of this country has, during the last twenty years, been extending their patronage of Science and the Arts. That this change was effected by the interference of the British Association, and by the writings and personal exertions of its members, could, were it necessary, be easily proved. But though men of all shades of political feeling have applauded the growing wisdom and liberality of the State, and though various individuals are entitled to share in the applause, yet there is one statesman, alas! too early and too painfully torn from the affections of his country, whom the science of England must ever regard as its warmest friend and its greatest benefactor. To him we owe new institutions for advancing science, and new colleges for extending education; and had Providence permitted him to follow out, in the serene evening of life and in the maturity of his powerful intellect, the views which he had cherished amidst the distractions of political strife, he would have rivalled the Colbert of another age, and would have completed the systematic organization of Science and Literature and Art which has been the pride and the glory of another land. These are not the words of idle eulogy, or the expressions of a groundless expectation. Sir Robert Peel had entertained the idea of attaching to the Royal Society a number of active members, who should devote themselves wholly to scientific pursuits; and I had the satisfaction of communicating to him, through a mutual friend, the remarkable fact, that I had found among the MSS. of Sir Isaac Newton a written scheme of improving the Royal Society precisely similar to that which he contemplated. Had this idea been realized, it would have been but the first installment of a debt long due to science and the nation, and it would have fallen to the lot of some more fortunate statesman to achieve a glorious name by its complete discharge.

It has always been one of the leading objects of the British Association, and it is now the only one of them which has not been wholly accomplished, "to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress." Although this object is not very definitely expressed, yet Mr. Harcourt, in moving its adoption, included under it the revision of the law of patents and the direct national encouragement of science, two subjects to which I shall briefly direct your attention. In 1831, when the Association commenced its labors, our patent laws were a blot on the legislation of Great Britain; and though some of their more obnoxious provisions have since that time been modified or removed, they are a blot still, less deep in its dye, but equally a stain upon the character of the nation. The protection which is given by statute to every other property in Literature and the fine Arts, is not accorded to property in scientific inventions and discoveries. A man of genius completes an invention, and after incurring great expense, and spending years of anxiety and labor, he is ready to give the benefit of it to the public. Perhaps it is an invention to save life—the life-boat; to shorten space and lengthen time—the railway; to guide the commerce of the world through the trackless ocean—the mariner's compass; to extend the industry, increase the power, and fill the coffers of the State—the steam-engine; to civilize our species, to raise from the depths of ignorance and crime—the printing press. But whatever it may be, a grateful country has granted to the inventor the sole benefit of its use for fourteen years. What the statute thus freely gives, however, law and custom as freely take away, or render void. Fees, varying from 200*l.* to 500*l.*, are demanded from the inventor; and the gift thus so highly estimated by the giver, bears the Great Seal of England. The inventor must now describe his invention with legal precision. If he errs in the slightest point—if his description is not sufficiently intelligible—if the smallest portion of his invention has been used before—or if he has incautiously allowed his secret to be made known to two, or even to one individual,—he will lose in a court of law his money and his privilege. Should his patent escape unscathed from the fiery ordeal, it often happens that the patentee has not been remunerated during the fourteen years of his term. In this case the State is willing to extend his right for five or seven years more; but he can obtain this extension only by the expensive and uncertain process of an Act of Parliament,—a boon which is seldom asked, and which through rival influence has often been withheld. Such was the patent law twenty years ago. Since that time it has received some important ameliorations; and though the British Association did not interfere as a body, yet some of its members applied energetically on the subject to some of the more influential individuals in Lord Grey's government,—and the result of this was, two Acts of Parliament passed in 1835 and 1839, entitled "Acts for amending the law touching letters patent for inventions." Without referring to another important Act for registering designs which had the effect of withdrawing from the grasp of the patent laws a great number of useful inventions depending principally on form,—I shall notice only the valuable provisions of the two Acts above mentioned, Acts which we owe solely to Lord Brougham. By the first of these Acts the patentee is permitted to disclaim any part either of the title of his invention, or of the specification of it, or to make any alteration in the title or specification. The same Act gives the Privy Council the power of confirming any patent, or granting a new one, when a patent had been taken out for an invention which the patentee believed to be new, but which was found to have been known before, but not publicly and generally used. By the same Act, too, the power of letters patent was taken from Parliament, and given to the Privy Council, who have, on different occasions, exercised it with judgment and discrimination. By the second Act of 1839 this last privilege was made more attainable by the patentee. These are doubtless valuable improvements, which inventors will gratefully remember; but till the enormous fees which are still exacted are either partly or wholly abolished, and a real privilege given under the great seal, the genius of this country will never be able to compete with that of foreign lands, where patents are cheaply obtained and better protected. In proof of the justness of these views, it is gratifying to notice that, within these few days, it has been announced in Parliament that the new Attorney-General has accepted his office on the express condition that the large fees which he derives from patents shall be subject to revision.

The other object of the British Association, mentioned by Mr. Harcourt, the Organization of Science as a National Institution, is one of a higher order, and not limited to individual, or even to English interests. It concerns the civilized world; not confined to time, it concerns eternity. While the tongue of the Almighty, as Kepler expresses it, is speaking to us in His Word, His finger is writing to us in His works; and to acquire a knowledge of these works is an essential portion of the great duty of man. Truth secular cannot be separated from truth divine; and if a priesthood has in all ages been organized to track and exemplify the one, and to maintain, in ages of darkness and corruption the vestal fire upon the sacred altar, shall not an intellectual priesthood be organized to develop the glorious truths which time and space embosom,—to cast the glance of reason into the dark interior of our globe, teeming with what was once life,—to make the dull eye of man sensitive to the planet which twinkles from afar, as well as to the luminary which shines above, —and to incorporate with our inner life those wonders of the external world which appeal with equal power to the affections and to the reason of immortal natures. If the God of Love is most appropriately worshiped in the Christian temple, the God of Nature may be equally honored in the Temple of Science. Even from its lofty minarets the philosopher may summon the faithful to prayer; and the priest and the sage may exchange altars without the compromise of faith or of knowledge. Influenced, no doubt, by views like these, Mr. Harcourt has cited the opinions of a philosopher whose memory is dear to Scotland, and whose judgment on any great question will be everywhere received with respect and attention; I refer to Prof. Playfair, the distinguished successor in our Metropolitan University of the Gregorys, the Maclaurins, and Stewarts of former days, who in his able dissertation 'On the Progress of the Mathematical and Physical Sciences,' thus speaks of the National Institute of France:—

> "This Institution has been considerable advantage to science. To detach a number of ingenious men from every thing but scientific pursuits—to deliver them alike from the embarrassments of poverty and the temptations of wealth—to give them a place and station in society the most respectable and independent, is to remove every impediment, and to add every stimulus to exertion. To this Institution, accordingly, operating upon a people of great genius and indefatigable activity of mind, we are to ascribe that superiority in the mathematical sciences which, in the last seventy years, has been so conspicuous."*

This just eulogy on the National Institute of France, in reference to abstract mathematics, may be safely extended to every branch of theoretical and practical science; and I have no hesitation in saying, after having recently seen the Academy of Sciences at its weekly labors, that it is the noblest and most effective institution that ever was organized for the promotion of Science. Owing to the prevalence of scientific knowledge among all classes of the French population, and to their admirable system of elementary instruction, the advancement of science, the diffusion of knowledge, and the extension of education are objects dear to every class of the people. The soldier as well as the citizen—the Socialist—the Republican and the Royalist—all look up to the National Institute as a mighty obelisk erected to science, to be respected and loved and defended by all. We have seen it standing unshaken and active amid all the revolutions and convulsions which have so long agitated that noble but distracted country—a common center of affection, to which antagonist opinions and rival interests and dissevered hearts have peacefully converged. It thus becomes an institution of order, calculated to send back to its contending friends a message of union and peace, and to replace in stable equilibrium the tottering institutions of the State. It was doubtless with views like these that the great Colbert established the Academy of Sciences in Paris, and that the powerful and sagacious monarchs on the continent of Europe have imitated his example. They have established in their respective capitals similar institutions—they have sustained them with liberal endowments—they have conferred rank and honors on their more eminent members, and there are now here present distinguished foreigners who have well earned the rewards and distinctions they have received. It is, therefore, gentlemen, no extravagant opinion that institutions which have thus thriven in other countries should thrive in ours—that insulated societies, which elsewhere flourish in combination, should when combined flourish among us—and that men ordained by the State to the undivided functions of science should do more and better work than those who snatch an hour or two from their daily toil or from their nightly rest. In a great nation like ours, where the higher interests and objects of the State are necessarily organized, it is a singular anomaly that the intellectual interests of the country should, in a great measure, be left to voluntary support and individual zeal—an anomaly that could have arisen only from the supineness of ever-changing administrations, and from the intelligence and liberality of a commercial people—an anomaly, too, that could have been continued only by the excellence of the institutions they have established. In the history of no civilized people can we find private establishments so generously fostered, so energetically conducted, and so successful in their objects as the Royal Societies of London, Edinburgh and Dublin, and the Astronomical, Geological, Zoological and Linnean Societies of the metropolis. They are an honor to the nation, and will ever be gratefully remembered in the history of science. But they are nevertheless defective in their constitution, limited in their operation, and incapable, from their very nature, of developing and directing and rewarding the indigenous talent of the country. They are simply subscription societies, which pay for the publication of their own transactions, and adjudicate medals intrusted to them by the beneficence of others. They are not bound to the exercise of any other function, and they are under no obligation to do the scientific work of the State, or to promote any of those national objects which are intrusted to the organized institutions of other lands. Their President and Council are necessarily resident in London, and the talent and the genius of the provinces are excluded from their administration. From this remark we must except the distinguished philosophers of Cambridge and Oxford, who, from their proximity to the capital, have been the brightest ornaments of our metropolitan institutions, and without whose aid they could never have attained their present pre-eminence. It is, therefore, in the more remote parts of the empire that the influence of a national institution would be more immediately felt, and nowhere more powerfully than in this its northern portion. Our English friends are, we believe, little aware of the obstructions which oppose the progress of science in Scotland. In our five universities there is not a single Fellowship to stimulate the genius and rouse the ambition of the student. The church, the law and the medical profession hold out no rewards to the cultivators of mathematical and physical science; and were a youthful Newton or Laplace to issue from any of our universities, his best friends would advise him to renounce the divine gift and to seek in professional toil the well-earned competency which can alone secure him a just position in the social scale and an enviable felicity in the domestic circle. Did this truth require any evidence in its support, we find it in the notorious fact that our colleges cannot furnish professors to fill their own important offices; and the time is not distant when all our chairs in Mathematics, Natural Philosophy, and even Natural History, will be occupied by professors educated in the English universities. But were a Royal Academy or Institute, like that of France, established on the basis of our existing institutions, and a class of resident members enabled to devote themselves wholly to science, the youth of Scotland would instantly start for the prize, and would speedily achieve their full share in the liberality of the State. Our universities would then breathe a more vital air. Our science would put forth new energies, and our literature might rise to the high level at which it stands in our sister land. But it is to the nation that the greatest advantages would accrue. With gigantic manufacturing establishments, depending for their perfection and success on mechanics and chemistry,—with a royal and commercial marine almost covering the ocean,—with steam ships on every sea,—with a system of agriculture leaning upon science as its mainstay,—with a net-work of railways demanding for their improvement, and for the safety of the traveler, and for the remuneration of their public-spirited projectors, the highest efforts of mechanical skill,—the time has now arrived for summoning to the service of the State all the theoretical and practical wisdom of the country,—for rousing what is dormant, combining what is insulated, and uniting in one great institution the living talent which is in active but undirected and unsupported exercise around us.

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* Diss. 3rd, Sec. V, p. 500.

In thus pleading for the most important of the objects of the British Association, I feel that I am not pleading for a cause that is hopeless. The change has not only commenced but has made considerable progress. Our scientific institutions have already to a certain extent become national ones. Apartments belonging to the nation have been liberally granted to them. Royal medals have been founded, and large sums from the public purse devoted to the objects which they contemplate. The Museum of Economic Geology, indeed, is itself a complete section of a Royal Institute, giving a scientific position to six eminent philosophers, all of whom are distinguished members of this Association. And in every branch of science and literature the liberality of the Crown has been extended to numerous individuals whose names would have been enrolled among the members of a National Institution. The cause, therefore, is far advanced; and every act of liberality to eminent men, and every grant of money for scientific and literary purposes, is a distinct step towards its triumph. Our private institutions have in reality assumed the transition phase; and it requires only an electric spark from a sagacious and patriotic statesman to combine in one noble phalanx the scattered elements of our intellectual greatness, and guide to lofty achievments and glorious triumphs the talents and genius of the nation. But when such an institution has been completed, the duties of the State to science are not exhausted. It has appreciated knowledge but in its abstract and utilitarian phase. It would be of little avail to the peace and happiness of society if the great truths of the material world were confined to the educated and the wise. The organization of science thus limited would cease to be a blessing. Knowledge secular and knowledge divine—the double current of the intellectual life-blood of man—must not merely descend through the great arteries of the social frame. It must be taken up by the minutest capillaries before it can nourish and purify society. Knowledge is at once the manna and the medicine of our moral being. When crime is the bane, knowledge is the antidote. Society may escape from the pestilence and may survive the famine; but the demon of Ignorance, with its grim adjutants of vice and riot, will pursue her into her most peaceful haunts, destroying our institutions, and converting into a wilderness the paradise of social and domestic life. The State has, therefore, a great duty to perform. As it punishes crime, it is bound to prevent it. As it subjects us to laws, it must teach us to read them; and while it thus teaches, it must teach also the ennobling truths which display the power and the wisdom of the great Lawgiver,—thus diffusing knowledge while it is extending education,—and thus making men contented and happy and humble while it makes them quiet and obedient subjects. It is a great problem yet to be solved, to determine what will be the state of society when man's physical powers are highly exalted, and his physical condition highly ameliorated, without any corresponding change in his moral habits and position. There is much reason to fear that every great advance in material civilization requires some moral and compensatory antagonism; but however this may be, the very indeterminate character of the problem is a warning to the rulers of nations to prepare for the contingency by a system of national instruction which shall either reconcile or disregard those hostile influences under which the people are now perishing for lack of knowledge.

Art. XXV.—*On the proper Height of Lightning Rods;* by Elias Loomis, Professor of Mathematics and Natural Philosophy in New York University.

Read before the American Association for the Advancement of Science at New Haven, August, 1850.

The rule prescribed by the French Academy of Science (and copied into almost all works on electricity,) for determining the proper height of a lightning rod is that a rod will protect a circle whose radius is equal to twice the height of the rod. A case recently occurred in Tallmadge, Summit County, Ohio, which appears to demonstrate that this rule is unsafe.

On the afternoon of July 27th, about six o'clock, there was a slight shower of rain accompanied by a few flashes of lightning. One flash was remarkably vivid, and was succeeded almost instantly by a loud report. In an instant afterwards, a large pile of shavings lying on the west side of a carriage shop was found in full blaze. The shavings had recently been carried out of the shop and were quite dry; and as no fire had been used in that vicinity for several weeks, and no other mode is known in which the shavings could have been ignited, it is inferred to have been caused by the electric discharge. The carriage shop was furnished with a lightning rod, and it was a matter of surprise that the fluid should have struck the ground so near to the rod. The top of the rod was fifty-nine feet high above the shavings; and the shavings were one hundred feet distant from a point vertically under the top of the rod. According to the rule above quoted, this rod should have afforded complete protection to a distance of one hundred and eighteen feet from its base; whereas the shavings were struck at a distance of one hundred feet, and that too where, being elevated only a few inches above the general level of the ground, they might be presumed to afford no peculiar attraction for the lightning.

This rod appears to have been constructed in accordance with the usual rules. It is terminated by three points which are gilded and appear to be in tolerably good condition. About ten feet from the top is a break in the rod and the two portions are looped together. From this point the rod is continuous to the bottom and enters the ground to the depth of about three feet where the earth at the time referred to was quite moist. The rod is about five-eighths of an inch in diameter.

The preceding case demonstrates to my mind that it is unsafe to rely upon a rod to protect a circle whose radius is more than once and a half the height of the rod, at least upon the west side, being that from which thunder showers generally come in this latitude.

Art. XXVI.—*On the Electrical Phenomena of Certain Houses;* by Elias Loomis, Prof. of Mathematics and Natural Philosophy in New York University.

Read before the American Association for the Advancement of Science at New Haven, August, 1850.

Within the past few years, several houses in the city of New York have exhibited electrical phenomena in a very remarkable degree. For months in succession they have emitted sparks of considerable intensity, accompanied by a loud snap. A stranger on entering one of these electrical houses, in attempting to shake hands with the inmates, receives a shock which is quite noticeable and somewhat unpleasant. Ladies in attempting to kiss each other are saluted by a spark. A spark is perceived whenever the hand is brought near to the knob of a door—the gilded frame of a mirror—the gas pipes—or any metallic body—especially when this body communicates freely with the earth. In one house which I have had an opportunity to examine, a child in taking hold of the knob of a door received so severe a shock that it ran off in great fright. The lady of the house in approaching the speaking tube to give orders to the servants, received a very unpleasant shock in the mouth, and was very much annoyed by the electricity until she learned first to touch the tube with her finger. In passing from one parlor to the other, if she chanced to step upon the brass plate which served as a slide for the folding doors, she received an unpleasant shock in the foot. When she touched her finger to the chandelier (the room was lighted with gas by a chandelier suspended from the ceiling) there appeared a brilliant spark and a snap as in the discharge of a Leyden Jar of good size. In many houses the phenomena have been so remarkable as to occasion general surprise and almost alarm.

After a careful examination of several cases of this kind, I have come to the conclusion that the electricity is excited by the friction of the shoes of the inmates upon the carpets of the house.

I have proved by direct experiment that electricity is excited by the friction of leather upon woolen cloth. For this purpose I stood upon an insulating stool, and spreading a small piece of carpeting upon a table before me, rubbed a piece of leather vigorously upon it, and then bringing the leather near the cap of a gold leaf electrometer, the leaves were repelled with great violence. The electricity of the leather was of the resinous kind. Electricity therefore must necessarily be excited whenever a person walks with a shuffling motion across a carpet; but it may be thought remarkable that the electricity should be intense enough to give a bright spark. In order to produce this effect there must be a combination of some favorable circumstances.

1. The carpet, or at least its upper surface, must be entirely of wool, and of a close texture, in order to furnish an abundance of electricity. So far as I have had opportunity to judge, I infer that heavy velvet carpets answer this purpose best. Two thicknesses of Ingrain carpeting answer very well. A drugget spread upon an Ingrain carpet yields a good supply of the fluid. The effect of the increased thickness is obviously to improve the insulation of the carpet.

2. The carpet must be quite dry, and also the floor of the room, so that the fluid may not be conveyed away as soon as it is excited. This will not generally be the case except in winter, and in rooms which are habitually kept quite warm. The most remarkable cases which I have heard of in New York have been of close, well-built houses, kept very warm by furnaces, and the electricity was most abundant in very cold weather. In warm weather, only feeble signs of electricity are obtained.

3. The rubber, that is the shoe, must also be dry, like the carpet, and it must be rubbed upon the carpet somewhat vigorously. By skipping once or twice across a room with a shuffling motion of the feet, a person becomes highly charged, and then upon bringing the knuckle near to any metallic body, particularly if it have good communication with the earth, a bright spark passes. In almost any room which is furnished with a woolen carpet, and is kept tolerably warm, a spark may thus be obtained in winter—but in some rooms, the insulation is so good and the carpets are so electrical, that it is impossible to walk across the floor, without exciting sufficient electricity to give a spark.

It may be said that in this case there can be but very little friction between the shoe and carpet. But it must be remembered that the rubber is applied to the carpet with considerable force, being aided by the whole weight of the body, so that a slight shuffling of the feet acts with great energy.

In the London and Edinburgh Philosophical Magazine for February, 1839, is given an account of a leather strap connecting the drum of a Worsted Mill, which gave sparks two inches in length, and charged a battery in a short time. The strap was twenty-four feet long, six inches broad, and one eighth of an inch thick. It crossed in the middle between the two drums, the strap forming a figure eight. Here then was considerable friction, since the strap made one hundred revolutions in a minute.

In the American Journal of Science for July, 1840, is mentioned an instance of a leather band in a cotton factory, which exhibited strong electrical excitement.

These examples show that leather when subjected to considable friction yields an abundant supply of electricity.

In the Proceedings of the American Philosophical Society for December, 1840, are mentioned several cases of individuals who drew sparks of electricity from a coal stove, and from a common grate. I consider it probable that in those cases the experimenter was the electrified body, and not the stove or grate. How is it possible for a grate containing burning coals, to be insulated, so as to retain a charge of electricity? On the other hand, it is presumed that the experimenter was insulated by standing upon a carpet made quite dry by a winter fire.

XXVII.—*On a new method of decomposing Silicates in the process of Analysis*; by Henry Wurtz, of New York.

Read before the American Association for the Advancement of Science, at New Haven, August, 1850.

Having had occasion in the course of some researches upon the greensand of New Jersey, which will be presented to the Association hereafter, to observe the facility with which that substance is decomposed by fusion with chlorid of calcium, it occurred to me that this property of the earthy chlorids might be applicable in the analysis of minerals.

Some experiments were accordingly made with reference to this supposition. Feldspar and hornblende were fused with chlorid of calcium, and it was found that the masses thus formed could be entirely decomposed by hydrochloric acid. The use of chlorid of calcium is however obviously attended with several inconveniences, such as its deliquescent properties, and the unavoidable introduction of a large quantity of ammoniacal salts into the solution, in the separation of the lime from it.

Chlorid of barium was therefore substituted, and the results of experiments upon this reagent were completely successful.

The chlorid of barium of commerce often contains lead, resulting probably from the leaden vessels in which it is crystallized. It is necessary in this case, to pass sulphuretted hydrogen through its solution. This solution is then filtered, recrystallized, and the washed crystals dried on the sandbath and ignited to drive off the water of crystallization. The pure chlorid of barium thus obtained is pulverized and is then ready to be used for the purpose here proposed.

Chlorid of barium may be fused in a platinum crucible by a blast lamp, or by an alcohol blowpipe lamp. A mixture of chlorid of barium and chlorid of strontium in atomic proportions fuses however far more easily than either of its ingredients. Such a mixture is fused by the heat of an ordinary Berzelius lamp, and more easily, I think, than carbonate of soda. This is analogous to the well known fact that a mixture of carbonate of soda with carbonate of potassa fuses more easily than either of the alkaline carbonates by itself. I have found moreover that although sulphate of strontia when precipitated by itself, appears in a form somewhat gelatinous, tedious to wash and difficult to filter, yet when precipitated in the presence of sulphate of baryta, it takes on the finely granular form of the latter, and the combined sulphates are as easily washed as the sulphate of baryta when precipitated alone.

The atomic proportions of a mixture of chlorid of barium and chlorid of strontium, suitable for the fusion of silicates, are about four parts of the former to three of the latter.

The best mode of proceeding was found to be as follows:—

The mineral in fine powder is intimately mixed with four or five times its weight of chlorid of barium, or of the mixture of chlorid of barium and chlorid of strontium, in a platinum crucible, which is then covered, and exposed to a heat sufficient to fuse the mass for twenty or thirty minutes. When cool, the mass is loosened by bending the crucible, and allowed to fall into a beaker glass. Water is then poured on it in sufficient quantity to dissolve the excess of chlorid of barium, or chlorid of strontium, and the undissolved portion allowed to subside to the bottom of the beaker. The clear solution is then poured off into a porcelain dish, and concentrated hydrochloric acid is poured upon the residue in the beaker. The precaution of removing most of the earthy chlorids by means of water before adding the acid, is necessary on account of the difficulty of decomposing the mass by the direct affusion of strong hydrochloric acid, owing to the insolubility of the chlorids of barium and strontium in this acid.

After the application of heat to the beaker until the residue contained in it is decomposed by the acid, its contents are also transferred to the porcelain dish, and the whole contents of the latter evaporated to dryness in the usual manner, for the separation of the silica. The filtrate from the silica is precipitated while hot with a slight excess of sulphuric acid, kept hot for half an hour, and then filtered. The filtrate from the sulphate of baryta, must contain all the constituents of the mineral except the silica, and these may be determined by the ordinary methods.

When the mineral thus treated contains sulphuric acid, it will evidently remain with the silica in the form of sulphate of baryta. A difficulty would also seem to occur when the mineral contains much lime, on account of the insolubility of its sulphate. This last difficulty is however obviated, in some degree, by the very considerable solubility of sulphate of lime in hydrochloric acid, a fact which must have been noticed by many chemists.

The first qualitative experiment was made with a specimen of colorless transparent orthoclase from New York island. This feldspar was fused with chlorid of barium, according to the above process, and the silica thus obtained was found, upon fusion with carbonate of soda, to be perfectly pure.

The next experiment was made upon a black crystallized hornblende, from Franconia, New Hampshire. The silica obtained from this was found to contain considerable more than a trace of iron. I do not therefore venture to recommend this proces at present for minerals which contain a very large quantity of oxyd of iron. Many more experiments which time has not permitted me to make, will soon be made to settle this question, which I do not consider yet determined.

To test the chlorid of barium process quantitatively, the mineral called pink scapolite, of Bolton, Mass., long ago analyzed by Dr. Jackson, was selected. My results agree entirely with his, except as regards the presence of lithia and oxyd of cerium, which careful qualitative examination did not enable me to detect.

This mineral was found, contrary to recorded statements, to be not completely decomposed by concentrated acids, even when finely elutriated. A determination of the silica, made by decomposition with hydrochloric acid, gave the per-centage 50·25; another, made by fusion with carbonate of soda, gave 47·55.

Two determinations of the specific gravity, made upon the identical portion of mineral which was analyzed, dried at 212° in coarse powder, gave the numbers 2·7002 and 2·7046.

The results of a fusion with chlorid of barium were as follows:

		Oxygen.	
Silica, ...	47·67	24·78	24·78
Alumina, . . .	25·75	12·035	12·71
Peroxyd of iron, . .	2·26	·68	
Lime, ...	17·31	4·82	7·08
Soda, ...	7·76	2·26	
Protoxyd of manganese,	*trace.*		
	100·77		

Agreeing nearly with the received formula of scapolite—

$$(\dot{C}a\ \dot{N}a)^3\ \dddot{S}i^2+2\ddot{\bar{A}}l\ \dddot{S}i,$$

which requires for the oxygen of the protoxyds, peroxyds and silica, the ratio 1 : 2 : 4, while the above analysis gives the ratio 1·14 : 2·06 : 4.

This method appears to possess advantages for decomposing silicates which contain both the alkalies, over the ordinary methods of fusion with the hydrate or with the carbonate of baryta. Hydrate of baryta generally acts upon the crucible, causing the mass to adhere to it; and upon the affusion of hydrochloric acid, any potash which the mineral may contain, consequently enters into combination as bichlorid of platinum and potassium, and remains with the silica. The carbonate of baryta process requires an intense heat, and is difficult of execution.

The chlorid of barium process proposed in this paper is probably not more laborious than an ordinary carbonate of soda fusion, and is applicable in cases in which the silicate contains both potash and soda.

Art. XXVIII.—*On the availability of the Greensand of New Jersey as a source of Potash and its Compounds;* by Henry Wurtz, of New York City.

Read before the American Association for the Advancement of Science, at New Haven, August, 1850.

The vast importance of potash and its compounds in the arts, long ago impressed upon chemists the necessity of finding some source of these compounds other than the ashes of the forests.

Accordingly, a great multitude of experiments have been made upon feldspar, by various chemists, in the hope of attaining this important end, but owing to the peculiar chemical and physical properties of feldspar, the success of these researches has been doubtful.

It is true that the feeble affinities exerted by mineral waters impregnated with carbonic acid, and even those of pure water itself, acting through hundreds of years, have been found sufficient to break down the constitution of this hard silicate, thus giving rise to vast beds of kaolin, but when it is attempted to effect the same thing within any reasonable time, by artificial means, it is found necessary to bring into play temperatures and forces too enormous in amount to be economical in practice.

I have not been able to ascertain that any one has yet proposed to use, as a means of obtaining the end under consideration, the vast deposits of the potash mineral called *Greensand,* which exist in the United States, and it is the object of the present paper to show that this substance is far superior to feldspar in its adaptation to this purpose.

The existence and common attributes of the greensand are generally known, but a few words on this subject will not be amiss. It exists in greater or less quantity in several States, but has its greatest development, I believe, in the State of New Jersey, where it forms a stratum of variable thickness, covering a great portion of the counties of Monmouth, Burlington, Gloucester and Salem. Wherever it occurs, it is spread upon the land in large quantities as a fertilizer, and is a source of wealth to the farmers, to whom it is known by the name of *Marl.* Its properties as a fertilizer are undoubtedly owing to the ease with which the potash which it contains is abstracted from it by atmospheric agencies, as is suggested by Prof. Henry D. Rogers, in his Report upon the Geology of New Jersey, in which he has devoted about a hundred pages to the greensand, and has given many analyses which indicate the presence of from 10 to 13 per cent. of potash. No analyst has, to my knowledge, found potash in the English greensand, the fertilizing properties of which appear to be due to the presence of phosphates.

The external appearances of the New Jersey *marl* are very various. Some varieties are almost entirely composed of grains of greensand, others contain variable proportions of a red or brown earth and of quartz. A few contain more or less carbonate of lime in such a form that it is not acted upon by dilute acids in the cold, although upon the application of heat a violent effervescence appears. Many contain iron pyrites and some a trace of sulphate of iron. No variety which I have examined has yielded any phosphoric acid.

The greensand grains themselves contain, besides potash, silica, alumina, one or the other or both of the oxyds of iron, and water, with sometimes a little magnesia.

The invariable development of a smell of formic acid by the action of strong sulphuric acid upon them, seems to indicate the presence of a little organic matter. Analyses of two varieties of the marl from the estate of the late Alfred Bishop of Bridgeport, at Shrewsbury, Monmouth County, yielded the following results:

	I.	II.
Silica,	48·24	47·83
Alumina and oxyd of iron, principally peroxyd,	32·89	34·98
Potash,	6·38	4·94
Magnesia,	2·60	
Hydroscopic water,	4·81	11·50
Combined water,	5·69	
	100·61	99·25

It may be remarked here that Prof. Rogers's results were obtained upon the greensand grains separated as much as possible from intermixed earth and sand, while the above were made upon the impure marl itself.

For more detailed information I must refer to the elaborate report of Prof. Rogers before mentioned. I will only state further that the greensand grains are easily pulverized, having only about the hardness of gypsum, and that they are decomposed by dilute acids, and we then come to the immediate subject of this paper.

Considering that the greensand contains the constituents of *alum*, with the exception of the sulphuric acid, it seemed probable that by the action of sulphuric acid upon it, a solution would be formed containing more or less alum. Many experiments were made and much time was spent upon this point without much success. It seemed as if the protoxyd of iron was dissolved by the acid much more readily than any other constituent of the marl, and also that the organic matter interfered in some way. The solutions obtained had generally a dark brown color and a smell resembling that of formic acid. They contained much sulphate of protoxyd of iron, and gave a few impure crystals of alum. A portion of the greensand was next gently ignited, which served the purpose of destroying the organic matter, if any was present, and also of peroxydizing the iron, thus rendering it less soluble in acids. The pulverized and ignited marl presented the appearance of a brownish red powder. It was easily decomposed by dilute sulphuric acid, yielding a solution, the contents of which, upon analysis, proved to be principally common alum, together with small quantities of iron-alum and of the persulphates of alumina and iron. The first crystals of alum obtained from a considerable mass of the solution were almost perfectly pure, and upon the addition of a small quantity of chlorid of potassium to the solution, it was found, as might have been predicted, that all the iron was converted into the uncrystallizable perchlorid, the sulphate of potash thus formed by double decomposition combining with the free sulphate of alumina to form common alum; and even in the last crops of crystals now obtained little or no iron could be detected. The manufacture of alum, therefore, by the action of sulphuric acid upon previously ignited greensand marl, promises to be successful beyond all anticipation. It is obvious that it will be necessary to select varieties of the marl as free as possible from lime and magnesia, which would cause a waste of acid.

My researches were next directed towards the production of chlorid of potassium. Attempts to form this substance by the direct action of hydrochloric acid upon the ignited marl were unsuccessful. A very large quantity of perchlorid of iron was formed, which would give rise to too great a loss of acid.

It was next found that by fusing together greensand and chlorid of sodium at a red heat, a hard mass was formed, which yielded with water a solution containing potash; but owing to the difficulty of separating chlorid of potassium from chlorid of sodium when the latter is present in greater quantity than the former, this observation was considered of little value.

A widely different conclusion was arrived at, when chlorid of calcium was substituted for chlorid of sodium. The pulverized and ignited marl was mixed with a sufficient quantity of chlorid of calcium to form upon the fusion of the latter, a pasty mass. The decomposition of the greensand takes place in this case at a low temperature, and is so complete that I have founded upon this circumstance a method of decomposing minerals in the process of analysis, which I have had the honor of presenting to the Association before.

It is evident that the combined water of the greensand must be expelled by ignition previous to fusing it with chlorid of calcium, otherwise a quantity of the fused chlorid of calcium will inevitably be decomposed by the steam evolved. The fusion may also be performed in close vessels to avoid the decomposition which chlorid of calcium undergoes when fused in contact with the air. The mass, after fusion, falls to pieces in water, yielding to this solvent, in most cases, all the potash which was contained in the greensand employed in the form of chlorid of potassium. The separation of this from the excess of chlorid of calcium is an easy problem, owing to the difference between their solubilities.

This application of the chlorid of calcium will open a market for the large quantities of this substance which are thrown away in some manufactories of soda-ash.

All attempts to procure sulphate of potash by the fusion of various sulphates with the greensand were unsuccessful. In fact, the greensand itself, at a temperature below the fusing points of the sulphates of lime and magnesia, fuses to a black glass which is no longer decomposable by acids.

A great number of other experiments were made upon the greensand, but no results were arrived at, which promise to be of any practical value except the above.

A very great number of experiments were also made, having for their object to obtain sulphate of potash by fusing together chlorid of potassium with alum and with various sulphates, such as those of iron, magnesia and zinc, which gave results of great practical value, but as these researches had but a fortuitous connection with those upon the greensand, I shall not introduce an account of them here.

I will merely remark that if sulphate of potash can be obtained by fusing together alum and chlorid of potassium, both of these being obtained economically from the greensand by the above processes, it is evident that this sulphate of potash may be treated in the same manner for the production of potash as sulphate of soda is in the manufacture of soda-ash, and it seems to me that the desideratum of another source of potash is thus supplied.

ART. XXIX.—*On the Diurnal and Annual Variations in the Declination of the Magnetic Needle, and in the Horizontal and Vertical Magnetic Intensities;* by Prof. W. A. NORTON.

IN my paper on the Diurnal Variations of the Magnetic elements, published in a former No. of this Journal,* I showed that the variations of the horizontal magnetic intensity which lie between the hours of 10 P. M. and 10 A. M. of the following day proceed *pari passu*, and are undoubtedly in some way physically connected with the variations that take place during the same interval of time in the quantity of moisture immediately at the earth's surface:—or at all events that the deviations from the general law of proportionality to temperature that occur during this interval are effects, direct or indirect, of the deposition of dew during the night, and evaporation of moisture during the morning hours. I accounted for the connection subsisting between such dissimilar phenomena by assuming that particles of water in contact with the earth's surface, (and possibly in the vaporous state,) had a direct magnetic action upon the needle, in accordance with the general theory that I had advanced. This is the simplest assumption that can be made in the case, but it is to be observed that the connection in question may possibly be attributable to some indirect effect of deposition and evaporation; as, for example, the disturbance of the electric equilibrium, which, as is well known, is attendant upon these phenomena, or the varying conduction of electrical currents, or some other cause. For the present, however, it is most philosophical to abide by that view which gives us the highest generalization—which represents, at the same time, the normal state of the earth's magnetism and its periodical variations.

It is true that we have no authority, derived from experiment, for supposing water to have a magnetic action, as the term magnectic is generally understood. It has only been established, by direct experiment, that water detached from the general mass of the earth, has what is called a diamagnetic action. But our first aim in such inquiries should be to obtain the highest generalization possible, from the discussion of the phenomena merely. The reconciliation of this generalization with the results of experiment is to be reserved for subsequent inquiry. Observation and experiment are here two independent paths converging to the same great truth. I would also remark, with regard to the meteorological discussion, incidentally entered into in the paper above referred to, concerning the thermal effect of dew, that this effect may perhaps have been overrated, and that the law of the nocturnal diminution of temperature may be partially attributable to the unequal cooling action of ascending currents of air, continuing during a portion of the night. Although the fact that this law obtains in the calmest nights, and the assertion so often repeated by meteorologists that in clear calm nights the temperature of the soil falls many degrees below that of the air a few feet above it, would seem to render such a supposition inadmissible. But, whatever view may be taken of the relative part performed by the dew in determining the law of the nocturnal loss of temperature, it is to be observed that it suffices for the explanation of the connection subsisting between this law and that of the nocturnal variations of the horizontal magnetic intensity; since it must be admitted that the tendency of the thermal influence of dew is to produce an inequality of loss of temperature of the same kind with that which actually obtains. However, if the inequality in the nocturnal decrease of temperature be not entirely attributable to the deposition of dew, it must then be admitted that the cause which coöperates meteorologically with the dew, may possibly also coöperate magnetically with it in determining the law of the nocturnal variations of the horizontal force.

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* See this Journal, ii ser., vol. viii, p. 35.

Having made these explanations and qualifying statements with reference to my former memoir, I propose now to show, from another point of view, the high probability of the truth of the explanation which I have there given of the diurnal variations of the horizontal force; and subsequently to discuss the annual variations of the magnetic elements.

A short time previous to the date of the publication of that memoir, I was led to make a comparison between the curves showing the diurnal variations of the horizontal force, (as given in the Report of the Meteorological and Magnetical Observations, made at the Girard College Observatory, 1840 to 1845,) with the curves showing the diurnal variations of the height of the barometer; and noticed that the following remarkable relations subsisted between them. *They each have two maxima and two minima, and the maxima of the one set of curves occur at very nearly the same hours as the minima of the other.* The same relations may be observed in the following tabular statement.

Hours of Daily Maxima and Minima of Horizontal Force and Barometer, at Philadelphia, for the year 1844.

	Horizontal Force.	Barometer.
Prin. Maximum, ...	3 to 4 P. M.	9 A. M.
Prin. Minimum, ...	10 A. M.	4 P. M.
Sec. Maximum, ...	5 A. M.	Midnight.
Sec. Minimum, ...	11 P. M. to Midnight.	4 A. M.

It will be seen that the hours of maxima and minima of the barometer differ by not more than one hour from the hours of minima and maxima of the horizontal force. If we make the comparison for other years, and also for the quarters of years, we find a similar approximate correspondence.

If we descend to a minute comparison, we find that the intervals between the precise hours of maxima and minima in some instances amount to as much as two hours; in fact that the secondary or morning minimum of the barometer sometimes precedes the secondary maximum of horizontal force by three or four hours. If it be imagined that the existence of so large occasional differences between the times of maxima and minima renders it improbable that there is any physical connection between the diurnal variations of the barometer and the diurnal variations of the horizontal force, it is to be observed that the variations both of barometer and horizontal force are comparatively small during the night, and also in general about the times of maxima and minima; and therefore that such comparatively small differences may be expected to subsist, unless the two phenomena be supposed to be identical in their origin. If the times of the maxima of the one element were always precisely the same as the times of the minima of the other, then it would seem highly probable that the diurnal variations of the horizontal force are in some way directly dependent upon the diurnal variations of the pressure of the air; as it is, the more probable conclusion is, that these two different phenomena are two different effects or consequences of the same meteorological phenomenon.

When I had arrived at this point in the progress of my investigations, it at once occurred to me that, as the diurnal variations of the horizontal force had been explained by referring them to the daily changes in the temperature and humidity of the earth's surface, the diurnal variations of the barometer were probably attributable to daily changes in the temperature and humidity of the air. It was seen that the same evaporation by day which tended to diminish the horizontal force, would tend, by adding to the quantity of vapor in the air, to augment the height of the barometer, and that the same condensation of vapor at the earth's surface at night, which tended to increase the horizontal force, would, by diminishing the quantity of vapor in the air, tend to make the barometer fall: also that if these tendencies, in conjunction with those due to variations of temperature, are the actual producing causes of the diurnal variations of the barometer and horizontal force, there would doubtless be an approximate correspondence between the maxima of the one element and the minima of the other. It is somewhat curious that I should have been conducted in this indirect manner, to the explanation of the daily variations of the barometer, which, as I have since found, has been conclusively established, to be the true explanation of this phenomenon, by direct observation. This is known to meteorologists as Dove's theory of the diurnal variations of the barometer. This theory, as stated by Kaemtz, is that the pressure of the atmosphere is equal to the sum of the pressures of dry air and aqueous vapor, and thus the barometric column is composed, so to speak, of two parts; one of which corresponds to the air; the other to the aqueous vapor. Now when the temperature rises the density of the air diminishes, but the tension of the vapor augments, and *vice versa.* To bring his theory to the test of figures, "he analyzed a set of observations made by Neuber at Apenrade with a Daniell's hygrometer. He calculated the tension of the vapor for each hour of the day, and subtracted it from the barometric column; he thus obtained the pressure of dry air, and found that it had but one maximum and one minimum, each day:"—the former, (at a mean for the year,) occurring at 1 A. M., and the latter at 2 P. M. Kaemtz adduces his own calculations, from other observations, as evidence against the theory of Professor Dove. But the results obtained by several other observers tend to confirm this theory. The following result was obtained from a discussion of the meteorological observations made at the Toronto Observatory, during the years 1841 and 1842. "The diurnal pressure of the gaseous atmosphere has one maximum which occurs about the coldest hour of the day, and one minimum which occurs about the warmest hour of the day. The elastic force of the vapor has also one maximum which occurs at 2 P. M., and one minimum at 4 A. M. The sum of these two pressures however exhibits two daily maxima, viz., at 10 A. M. and P. M., and two daily minima, viz., about 3 or 4 A. M. and P. M. Thus this knotty question respecting the diurnal oscillations of the barometer has been beautifully resolved by simply interrogating nature." A similar conclusion may be drawn from the hourly meteorological observations made during the year 1842 at the following places in Russia, viz., St. Petersburg, Barraoul, Catharinenburg, and Sitka.* It is true that small irregularities are noticed, but as the same general law appears to exist everywhere, it is to be supposed that such irregularities supervene upon it at particular localities by reason of certain local peculiarities.

That the explanation of the diurnal variations of the barometer, upon Dove's theory, corresponds precisely to that which I have given of the diurnal variations of the horizontal force will be readily seen. In the morning, as the temperature rises the pressure of dry air diminishes, but the tension of the vapor which forms over-compensates this effect, and thus the barometer rises. This continues until about 9 A. M. After this the diminution in the pressure of dry air prevails over the increase due to the augmented quantity of vapor, and the barometer falls until 3 or 4 P. M. When the temperature begins to fall the barometer also descends by reason of the increase in the density of the air: but in the evening, when a portion of the atmospheric vapor begins to fall in dew, a tendency to a diminution of the barometric pressure arises, but it is not until about midnight that this tendency begins to prevail over the tendency to an increase. From that time the barometer falls, from this cause, until towards the hour of minimum temperature.

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* See this Journal for January, 1846, pp. 138, 139, 140.

The explanation which I have before given of the diurnal variations of the horizontal force is, in substance, as follows. In the morning as the temperature rises the molecular magnetic force increases, and therefore the horizontal force tends to increase, but the diminution arising from the evaporation going on at the earth's surface over-compensates this tendency, and hence the horizontal force, on the whole, decreases. This continues until about 10 A. M. After this the increase, from the rise of temperature, prevails over the diminution produced by the continued evaporation* until about 4 P. M. From that time the horizontal force decreases with the temperature until about 11 P. M.; when the tendency to increase resulting from the deposition of dew begins to prevail over the opposite tendency resulting from the falling of the temperature. This second augmentation continues until about 5 A. M.

In view of what has now been stated it will, I think, be admitted that the diurnal variations both of the horizontal magnetic force and of the barometer are in all probability certain effects resulting from the joint operation of the same two general antagonistic causes—viz., variations of temperature and variations of humidity. The theory of the variations of the horizontal force which I have advanced is in accordance with the fact of the apparent connection subsisting between these phenomena. Other theories may perhaps be devised, equally in accordance with this singular fact; and indeed it must be conceded that it is strongly suggestive of the idea that the cause of the variations of the horizontal force, like that of the variations of the barometric column, must subsist in the atmosphere. In fact if it be admitted that the particles of the atmosphere and of the atmospheric vapor have a magnetic action upon the needle, like those of the solid mass of the earth, then it is a simple consequence of the principles of the general theory under consideration that the horizontal force will vary, by reason of this action, after the manner in which it is observed to do. For, the greater portion of the atmosphere being posited above the needle, the tendency of its action will be to diminish the horizontal force; and therefore when the number of particles of humid air increases immediately above the needle and the barometer falls, the horizontal force will diminish. Whether the atmosphere has really any effect, and if so, what portion of the observed changes is due to it, and what to the action of the varying temperature and humidity of the surface of the ground, cannot, perhaps as yet be established with certainty. The occasional occurrence in the atmosphere of the luminous magnetic phenomenon, called the Aurora Borealis,—a phenomenon which, (as I think may be clearly shown,) is also dependent upon the same two meteorological elements, viz., *temperature* and *humidity*—seems to favor the idea of atmospheric magnetic action: but, if it be conceded that, as is generally supposed, electrical currents flow along the auroral columns, we have in these currents apparently a sufficient explanation of the magnetic action of the aurora, and have therefore no good ground for supposing that the atmosphere has a magnetic action in its normal state. We may, however, still conjecturally connect the aurora with the diurnal variations of the horizontal magnetic intensity by imagining that the daily changes of temperature and humidity of the atmosphere are attended with electrical currents which traverse the atmosphere without producing any perceptible luminosity, or perhaps any other perceptible effects, except upon the magnetic needle.

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* It is to be observed that we are here speaking of the average state of things in the course of a year, or quarters of a year.

The philosophical course for the present, however, is to abide by the theory which furnishes the most direct representation possible of the connection subsisting between the barometric and magnetic variations, and at the same time accords with a general theory that satisfies the conditions imposed by the normal state of the earth's magnetism.

Annual Variations of the Horizontal Magnetic Intensity.

It having been established (or at least rendered in the highest degree probable) that the diurnal variations of the horizontal magnetic intensity are due to changes in the temperature and humidity of the earth's surface (or atmosphere), we naturally seek for the explanation of the annual variations of the horizontal force in annual changes of temperature and humidity. We have moreover seen that the diurnal variations of the horizontal force and barometer are linked together, and due to the same two general causes. It is therefore to be inferred that a similar connection must subsist between the annual variations of the horizontal force and barometer, and that the two phenomena must be other parallel effects of changes of temperature and humidity. Now if we compare the curve showing the variations of the horizontal force from month to month with the corresponding curve for the barometer, we in fact find an approximate correspondence between the maxima of the one and the minima of the other.* In the midst of irregular variations the following general law is very manifest in the curve of the barometric variations, viz., there is a maximum in January (or thereabouts), a minimum in the spring, another maximum about August, and another less decided minimum in the fall. This law has also been revealed by the observations made in Europe. It is stated as follows by Kaemtz, (Cours Complet de Meteorologie, p. 282.) "Setting out from winter the pressure" (of the air) "diminishes until the equinox, then it augments in summer without attaining nevertheless to the winter mean; we afterwards find in autumn traces of the second minimum, then the curve rises again until winter." The same law is also manifest in the curve for the horizontal force, substituting maximum for minimum and minimum for maximum. Before noticing this connection between the annual variations of the horizontal force and of the height of the barometer, I inferred from my previous investigations that the following was probably the true explanation of the annual variations of the horizontal force.

From the winter to the summer this force tends to increase by reason of the increase of temperature, and to diminish by reason of the loss of moisture from the earth's surface (or increase of vapor in the air). For a time the first cause prevails over the second and thus the force augments. But the formation of vapor will be proportionally more and more rapid for the same rise of temperature, and thus it happens that some time during the spring the tendency to a diminution of the horizontal force comes to prevail over the tendency to an increase. This state of things continues until the time of maximum temperature (July or August). After this for a certain time the temperature will fall without a proportionate diminution in the quantity of vapor in the air; and thus the horizontal force will continue to decrease for a certain time beyond the time of maximum temperature. But we may expect that during the autumn the rapid diminution in the quantity of vapor in the air will give rise to an opposite tendency; which will continue until the effect of the average daily loss of vapor (being proportionally less from day to day) comes to be overbalanced by the opposite effect of the diminution of temperature. Thus there may be a second maximum in the fall, followed by a minimum in the winter. While this would be the general course of things, there would be room for material irregularities in individual years.

This explanation of the annual variations of the horizontal magnetic intensity I find to be substantially the same, *mutatis mutandis*, as that given by Professor Dove of the corresponding variations of the height of the barometer. He has established that the pressure of dry air has but one maximum and one minimum during the year,—the former in the winter and the latter in the summer. The tension of the atmospheric vapor, on the other hand, attains its minimum in the winter and maximum in the summer. From the combination of these two pressures there results two maxima and two minima of actual pressure, as previously stated. There is "a minimum in the spring because that then the pressure of dry air diminishes rapidly, while the quantity of vapor is not yet very considerable. We find traces of a second minimum in autumn because the quantity of aqueous vapor diminishes rapidly, while the pressure of dry air increases slowly."

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* See Plates in Report of Observations at Girard College Observatory.

It must accordingly be admitted to be highly probable that the annual variations of horizontal magnetic intensity are attributable to the combined operation of the same two general antagonistic causes as the diurnal variations, viz., variations of temperature and variations of humidity. It must also be admitted that the existence of such a connection between these diurnal and annual magnetic and meteorological phenomena is a necessary inference from the Thermal Theory of Terrestrial Magnetism; and that this theory furnishes a rational and consistent explanation of the laws of the magnetic variations.

Annual Variations of the Vertical Magnetic Intensity.

On examining the curve showing the annual variations of the vertical magnetic intensity at Philadelphia for the years 1841 to 1845, we find that the general law is that the intensity is greatest about June or July, and least about December or January. To this general law an exception occurs in the year 1841—the force decreasing, instead of increasing, from the first of the year until July, and then increasing until November, after which there is a decrease in accordance with the general law. Now it will be recollected that, agreeably to the theory under consideration, the vertical magnetic force is dependent upon the differences of temperature between the station of the needle and all places situated to the north or south of this station, within the circle of sensible magnetic action. We have therefore to enquire whether these differences observe the same law of variation as the vertical magnetic intensity; and also whether there is any exception to the general law, corresponding with that above mentioned, during the year 1841. The observations which I have obtained suited to this inquiry, (viz., the mean monthly temperatures at Washington, Newtown, Port Carbon, and Silver Lake, for 1841 and a part of 1842, and at Trenton for 1842) furnish results which accord, for the most part, with the theory. But as these results are confined to one or two years, no certain conclusion can be drawn from them; I shall accordingly reserve this discussion for a future occasion.

Annual Variations of Declination.

According to the theory under consideration the annual variations of declination are attributable to the annual variations in the position of the isothermal line—or rather, to be precise, of the line of equal molecular magnetic intensity, which must approximate more or less to the isothermal line. Now the annual movements of the isothermal line may be ascertained by discussing the annual variations that take place in the differences between the mean monthly temperature at Philadelphia and at some place to the east or west of Philadelphia;—that is, supposing that the law of the variation is the same whatever place so situated with regard to Philadelphia be taken. The following table shows the mean monthly differences of temperature for 1841, between Philadelphia and several places to the west of Philadelphia.

Mean Monthly Differences of Temperature for 1841.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	A'g.	Sept.	Oct.	Nov.	Dec.
Phila. and Lancaster,	...	3°·38	1°·59	0°·06	0°·23	0°·38	0°·91	...	0°·93	1°·50	4°·16	4°·71
" and Gettysb'g,	...	5·23	3·44	2·05	−0·09	1·89	2·13	...	1·89	−15·88	5·09	4·70
" and Carlisle,	...	...	...	3·5	1·9	−1·5	....	...	....	−15·0	5·9	7·3
" and Harrisb'g,	...	4·9	2·32	−0·70	....	−2·8	−1·1	...	−2·1	− 4·5	3·4	4·7
" and W.Chest'r,	...	...	4·3	2·2	1·3	....	....	...	....	.....	....	4·7

It will be observed that the mean monthly differences of temperature for all these places are greater at the beginning and end of the year than toward the middle of the year. The minus sign indicates that the temperature at Philadelphia is less than at the other place.

It appears from these results that during the year 1841, the temperature at places to the west of Philadelphia, from being less than that at Philadelphia at the beginning of the year, became equal to it, or greater, toward the middle of the year, and less again at the close of the year. The isothermal line through Philadelphia must therefore, on the west side of Philadelphia, have moved towards the north during the first part of the year, and towards the south during the latter part of the year. The tendency of these movements would be to make the declination least toward the middle of the year and greatest at the beginning and end of the year. Now, as a matter of fact, on examining the curve given in the Report of the Observations at the Girard College Observatory, showing the annual variations of declination at Philadelphia, we find that in 1841 the declination was greatest in January and February, and again in November and December, and least in April and May. On inspecting the table given above, it will also be seen that an irregularity occurs in the month of October. In the curve of the declination there is a corresponding irregularity; the declination was less in October than in September, and much greater in November than in October.

The curve of annual variations of declination above referred to, shows that the same general law obtained during the entire period of the observations comprised between June, 1840, and the beginning of 1844. The following table shows that the variations of the difference of temperature between Philadelphia and Lancaster followed the same law during this period.

Mean Monthly Differences of Temperature between Philadelphia and Lancaster, Pa.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1840......	....					-1°·4	-1°·9	-2°·3		-0°·8	-0°·7	-0°·3
1841......		3°·38	1°·50	0°·06	0°·23	0·38	0·91	....	0°·93	1·50	4·16	4·71
1842......	1°·1	2·2	-0·5	-2·3	0·8	1·2	1·7	-0·9	-0·7	1·1	1·9	1·6
1843......	....	....	.....	-0·3	-1·5	-0·4	-1·3	1·0	-0·6	0·4	0·0	-0·2

The temperatures at Philadelphia used in the calculations are those given in the Report of the Girard College observations, except in the case of the year 1841, for which the temperatures published in the Journal of the Franklin Institute were used. The temperatures for Lancaster were obtained from the Journal of the Franklin Institute and from the original manuscripts of Dr. W. M. Atlee's Reports to the Franklin Institute which he had the kindness to place in my hands. The observations for Gettysburg, Carlisle, Harrisburg, and W. Chester were also obtained from the published reports to the Franklin Institute, under the general system of meteorological observation established by this Institute. The daily observations were made at 7 A. M., 2 P. M., and 9 P. M.

It is to be observed that the comparatively large plus differences of temperature that occur in the year 1841, as given in the above table, are to be attributed to the fact that the temperatures at Philadelphia as reported to the Franklin Institute are higher than as given in the Girard College observations. Making use of the latter we obtain for the

Differences of Temperature between Philadelphia and Lancaster for 1841.

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1°·0	-1°·8	-2°·6	-3°·0	-3°·1	-4°·1	-2°·9	-1°·3	-0°·5	-1°·8	-0°·1	0°·6

The results which we have obtained leave little room to doubt that the principal annual movements of the needle are connected with certain corresponding movements of the isothermal line;

and that the connection is such as our theory calls for. The question of this connection cannot however be definitively settled until we have obtained a longer series of observations, and at a greater number of places.

General Results.

It may be well to recapitulate here the more important results arrived at in this and the previous memoir.

1. The diurnal and annual variations of the horizontal magnetic intensity are due to the joint operation of two general antagonistic causes, viz., variations of temperature and variations of humidity.

2. The diurnal and annual variations of the height of the barometer (or pressure of the air) are attributable to the same general causes;—with this probable difference, that in one case the effects result directly from changes in the temperature and humidity of the air, and in the other from changes in the temperature and humidity of the earth's surface.

3. The variations of horizontal magnetic intensity and of barometric height follow the same law; with the single exception, that the maxima of the one element occur at the same hours as the minima of the other.

4. The observed variations of the horizontal magnetic intensity are legitimate consequences of the thermal theory of terrestrial magnetism; granting that moisture has a magnetic action.

5. The deviations, in the variations of the horizontal force, from the general law of proportionality to temperature, are modifications produced by the deposition of vapor from the atmosphere and the evaporation of the same from the earth's surface. In the case of the diurnal variations these effects (taking the mean of three months' variations) are confined chiefly to the interval between sundown and the hour of 10 A. M. on the following day.

6. Taking the mean for three months, the amount of the decrease of the horizontal force during the morning hours depends chiefly upon the quantity of rain that falls.* The explanation of this dependence is that the diminution of this force in the morning is owing to the evaporation which then occurs, and the average amount of this evaporation must be mainly dependent upon the average quantity of rain that falls.

7. The deposition of dew at night which has the effect to check, and even overcome the diminution of the horizontal force due to the fall of the temperature, exerts also an important influence in moderating the nocturnal decrease of temperature, which does not appear hitherto to have been recognized.†

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* See this Journal, 2nd ser., vol. viii, Number for Nov., 1849, p. 353.

† See this Journal, 2nd ser., vol. viii, Number for Sept., 1849, p. 226.

8. The diurnal variations of the vertical magnetic intensity are, for the most part, in accordance with the idea that they arise from variations in the difference between the temperature at the station of the needle and the temperature at a place to the north or south of it.

The annual variations of vertical force and difference of temperature also appear to proceed *pari passu* with each other; but the observations hitherto discussed are too limited to settle definitively the question of natural dependence.

9. There is an undoubted connection between the diurnal variations of the declination and those of the horizontal force. This connection may be described as follows: when the curve showing the diurnal variations of the horizontal force is concave upward, the declination (westerly) is increasing; and when the curve is convex upward, the declination is decreasing. As a consequence the maxima and minima of declination must be cotemporaneous with the points of inflexion of the curve of horizontal force.*

10. This connection accords with our theory, agreeably to which the declination varies with the shifting position of the line of equal molecular magnetic intensity;—which line must be very nearly coincident with the line of equal horizontal magnetic force. The line in question differs from the true isothermal line by reason of the modifications of the horizontal force induced by changes of humidity.

11. The annual variations of declination appear to be mainly dependent upon an annual oscillatory movement of the isothermal line. This result accords with the theory if we grant that, taking the monthly means, the isothermal line will differ but little from the line of equal molecular magnetic intensity. We know that these lines must approximate more or less to each other. The degree of approximation can only be directly ascertained by a detailed and extended discussion.

ART. XXX.—*On the Analogy between the mode of Reproduction in Plants and the "Alternation of Generations" observed in some Radiata;* by JAMES D. DANA.

Read before the American Association for the Advancement of Science at New Haven, August, 1850.

THE very remarkable fact that a Polyp and a Medusa may be in some instances different states of one and the same species, has been well established of late by the researches of Sars, Dalyell, Steenstrup, and others; and recent important observations have been made on the subject by Professor Agassiz. The alternations are as follows:—

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* See this Journal, 2nd ser., viii, 360, 361.

1. The Medusa produces eggs;—
2. The eggs, after passing through an infusorial state, fix themselves and become polyps, like Corynæ, Tubulariæ, or Campanulariæ;—
3. The polyps produce a kind of bud that finally drops off and becomes a Medusa.

Thus the egg of a Medusa, in such cases, does not produce a Medusa, except after going through the intermediate state of a polyp.

Or if we commence with the polyp, the series is thus:—

1. The polyp produces bulbs that become Medusæ;
2. The Medusæ produce eggs;
3. The eggs produce polyps.

This is what is called by Steenstrup "Alternation of Generations;" and he considers the earlier generation as preparing the way for the latter. It certainly seems to be a most mysterious process:—a parent producing eggs which afford a progeny of wholly different form, (even so different, that naturalists have arranged the progeny in another grand division of the Radiata); and this progeny, afterwards, by a species of budding or gemmation repeating the form of the original parent.

Yet although seemingly so mysterious, is not this mode of development common in the vegetable kingdom? Is it not the prevalent process in the plants of our gardens and fields, with which we are all familiar?

It is well known to us, that in most plants, our trees and shrubs for example, growth from the seed brings out a bud of leaves; from this bud after elongation, other leaf-buds are often developed, each consisting like the first of a number of leaves. It is an admitted fact (as may be found in Treatises on Vegetable Physiology) that each of these buds is a proper plant-individual, and that those constituting a tree are as distinct and independent as the several polyps of a compound zoophyte; and that the tree therefore is as much a compound group of individuals, as the zoophyte. In some cases the plant forms but a single leaf-bud; in others, where there is successive gemmation for a period, the number is gradually multipled, and more or less according to the habit of the species. So among polyps, there is the simple and compound Tubularia, Campanularia, and the like.

After the plant has sufficiently matured by the production and growth of its number of leaf-buds, there is a new development—a flower-bud,—consisting of the same elements as the leaf-bud, but wholly unlike it in general appearance—as much so, as the Medusa is unlike the polyp. The flower-individual starts as a bulb from the leaf-individual, or the group of leaf-individuals, and is analogous in every respect to the bulbs from the Campanulariæ and allied species; and when it has fully matured, it produces, like the Medusa, ovules or seed—these seed to begin the round again of successive or alternating developments.

Thus among plants the seed produce leaf-individuals; these yield bulbs or buds becoming flower-individuals; and these produce seeds; precisely, as the egg produces polyps, the polyps, bulbs that develop into Medusæ, and the Medusæ, eggs.

When we follow out this subject minutely, we find the analogy completely sustained even in minor points of structure and growth. The leaf-bud consists of leaves developed in a spiral order; and in the polyp, as some species show beyond doubt, the tentacles and corresponding parts are spiral in development. The same spiral character is found in the flower, but the volutions are so close as not to be distinguished readily from circles. In the Medusæ referred to, the regularly circular form is far more neatly and perfectly developed than among the polyps—as is clearly seen in a comparison of the polyp Coryna, with the elegant Sarsia, a species of which is described and beautifully delineated in Professor Agassiz's recent memoir, published by the American Academy of Arts and Sciences at Boston. The relations in structure between plants and polyps might be farther dwelt upon; but for other observations the writer would refer to his volume on Zoophytes.

The only point in which the analogy seems to fail, is that the Medusa-bud falls off before its full development, while this is not so with plants. But it is obvious that this is unimportant in its bearing on this subject. It is a consequence of the grand difference in the mode of nutrition in the two kingdoms of nature; for the plant-bud on separation loses its only means of nutriment.

The law of alternating generations is therefore no limited principle, strange and anomalous, applying only to a few Radiata. It embraces under its scope, the vegetable kingdom, and it is but another instance of identity in the laws of growth in the two great departments of life.

Art. XXXI.—*On Electro-magnetism as a Moving Power;* by Prof. Chas. G. Page.

Note.—We are expecting from Prof. Page a description by himself of his new electro-motive engine: and in the mean time give a brief explanation of its fundamental principle, with the following Report to the Secretary of the Navy upon the progress of his investigations.

It is well known that when a helix of suitable power is connected with the poles of a battery in action, that an iron bar within it will remain held up by the induced magnetism although the helix be put in a vertical position: and if the bar be partly drawn out of the helix by the hand, it goes back with a spring when the hand lets go its hold. This power—the action of the helix upon the metallic bar within it,—is the power used in his engine. The power, when a single coil is used, has its points of greatest and weakest force, and in this condition is objectionable. But by making the coil to consist of a series of short independent helices, which are to be brought in action successively, the metallic rod is made to pass through the coil and back again with great rapidity and an equable motion. In all the engines hitherto used, there is a loss of power at the instant of the change of current, owing to the production of a secondary current moving in the opposite direction, and to this loss is owing the fact that these engines cannot be rendered available. Prof. Page had in view the obviating of this difficulty when he commenced his recent investigations, and has full success in his new invention.

The report below is an outline only of his experiments on the application of Electro-magnetism, and is dated, Aug. 3d, 1850. We take the Report from the National Intelligencer of September 4.—Eds.

From the brief time allowed, it will be impossible for me to do more in this respect than to give an outline of the experiments which I have repeated and recorded during the past year. Their full detail and explanation will form a volume, replete with interesting scientific matter, and require much time and labor.

The first principal experiments were made with a small trial engine, built expressly for the purpose, and with the utmost care in reference to mechanical accuracy. Attached to this was a dynamometer of new construction, and admirably adapted to the purpose. This was invented by my principal engineer, and measured in a most satisfactory manner the dynamic power of the engine, at any given velocity—a great desideratum in estimating this new power. With this trial engine the following important questions were tested:

1. The dynamic values of different qualities of soft iron.
2. The dynamic values of steel, hard and soft.
3. The dynamic value of cast iron.

The statical values of all these varieties were tested by a separate apparatus, constructed for the purpose, called the axial galvanometer. Twelve varieties in all were tested, and were in bars of uniform size, one foot in length, and one inch in diameter, and it was found that the statical and dynamic properties corresponded.

4. The proportions of the helices were approximately tested, though much remains unsettled yet upon this important point.

5. The advantages of keeping up the magnetism in the axial bar was most satisfactorily tested.

6. Various modes were tried of reversing the motion of the engine, and with success.

7. Various kinds of cut-off (which is the most critical and important point in the construction of the engine) were tried.

8. The operation of closed circuits and secondary currents was tested by a number of experiments, requiring great care and accuracy.

9. The best working velocity of this engine, and its absolute power with a given battery, was fully tested.

10. The ratio of increase of power, with an increase in the quantity of the current.

11. The values of different kinds of metal in forming the cut-off.

12. Various mechanical points of construction, supposed to have been incompatible with the exhibition of this power, were put to a practical test.

Various other minor points also were the subject of experiment, which will be communicated hereafter.

A second model, of small size and somewhat rude construction, was also made, with a view of testing a new arrangement of the axial bars.

Experiments were then commenced upon a larger scale, with a view to determine whether the same proportion of power could be obtained from large as from small engines, this being the principal question in view at the time of the grant of the appropriation.

With a view to facilitate the construction of helices of large size, a machine which had long been in contemplation was made at a considerable expense. The work was done at the Navy Yard in a creditable manner, and the machine performed its work well, turning out entire helices of copper wire, of large size, from straight bars. But before I had proceeded far, a discovery was made in reference to the helix, which rendered the machine useless; for the present at least.

A number of large helices were then constructed of various sizes, and suitable bars of soft iron prepared, corresponding to the helices. Hollow and solid bars were prepared, from two inches to eight inches in diameter, and generally three feet in length. Some bars of four and five feet in length were also prepared. The bars were all worked at the Navy Yard, and at a considerable expense, as they were required to be of homogeneous metal, accurately turned and bored.

With these bars and helices, a multitude of experiments were performed and recorded, and these were kept up day after day for about two months. My official duties as Examiner in the Patent Office left me only the evening of each day for operation; and, under such circumstances, you will readily appreciate the difficulties and disadvantages under which I have labored. My own zeal has led me beyond my strength; but I have been richly rewarded by the most flattering results.

The experiments here were not such as could be performed upon the laboratory table; but were with large masses of iron, weighing in some cases three hundred pounds, and helices sometimes twice that weight.

Adhering to the same size of battery through a long series of experiments, and varying the coils and bars, I found, to my great gratification, that as I increased the dimensions of each, a corresponding increase of power was exhibited, and the consumption of material, or cost of the power, in some proportion diminished. These results were encouraging and stimulating in the highest degree, and fully justified the undertaking at once of an engine upon a much larger scale than any hitherto tried.

This engine, the frame-work of which was principally built at the Navy Yard, was an upright engine of two feet stroke; and in order to have facilities for comparative trials and experiments, it was necessary that a double engine should be made, the two parts exactly corresponding. Two bars of soft iron, six inches diameter and three feet in length, were the prime movers, and these were balanced by means of connecting rods and cranks upon a fly-wheel shaft. The balance wheel and shaft together weighed six hundred pounds. When this engine was first tried, with the same battery which had before given me one-fifth of a horse power, with a smaller engine, it produced only one-third of a horse power. By careful attention to the adjustments, and particularly to the cut-off, which was a very different thing now from what it had been in smaller engines, the engine soon yielded one horse power. Here was a gain of eighty per cent. as measured merely by the size of the battery. But it was much more; for the cost was found to be less for one horse power than it had been before for one-fifth of a horse power, in a smaller engine; how much less has not yet been ascertained.

A great variety of experiments were continued with this engine, to be hereafter detailed, each having a definite object; and, I am happy to say, each resulting advantageously, so that finally, by little daily increments, I obtained from this engine, by a trifling addition of battery, a full two horse power.

By way of giving a practical character to the engine, it was geared to a circular saw ten inches diameter, the turning-lathe and grindstone of the workshop, all of which it worked simultaneously, as witnessed by a number of visitors, and, if I mistake not, by your predecessor in office, in company with Lieut. Maury, of the National Observatory.

After many satisfactory trials with this engine, it was taken down, and all its available parts used in the construction of the single horizontal engine which I had the honor lately to exhibit before the Smithsonian Institution. This change was made for the purpose of dispensing with the dead weight of one of the driving bars, and more particularly for introducing the important feature of keeping up the magnetism of the driving bar. As soon as this new form was completed and tried, a gain of one-half horse power was at once realized, and by the addition of a few more feet of battery surface, the power was found to be above four-horse. Further addition of battery would still augment the power, and I see no reason why ten horse power might not be obtained from this engine, by the addition of more battery; but whether it would be economical to increase power by this means alone, and to ascertain the point, for this and every other engine, beyond which economy would cease by increasing the battery alone, are matters to be determined by experiment.

The next most important point to be determined was the expense of this power. Much to my own surprise and gratification, the expense was found to be less than the most expensive steam engines, although recently, in Europe, it has been decided by experimenters and men of science, and generally conceded, that it was fifty times the cost of the dearest steam engines; but this is no obstacle to its introduction, considering its immense advantages in other respects. Moreover, if thus much has been done in the very inception of this undertaking, what may we reasonably expect from its further prosecution?*

Before it can be rendered available in practice, much remains to be done with the galvanic battery, to render its action regular and durable, and in other ways to establish a certainty of action, so that the engines may be managed by persons not thoroughly skilled in the subjects of electricity and magnetism.

It remains yet also to be proved whether the power will increase in proportion to the size of the engines. This principle seems to be strongly indicated by past experiments; but yet it cannot be established by calculation or process of reasoning. Experiment upon an extensive scale can alone determine this point. A part of the work preparatory to building a locomotive engine has been done; but it seems necessary to try further experiments before incurring the expense of another large engine upon the plan above mentioned. The rotary form of the engine has not yet been tested, although it possesses advantages not to be found in any form of the reciprocating engine. There are some obvious disadvantages attending its construction; but it is hoped that they will be outweighed, more especially as this form of the engine will occupy less than one-half the room required for the reciprocating form.*

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* Prof. Page, as mentioned in our last number, stated in his remarks before the American Association, that one horse power for twenty-four hours, would cost about 20 cents. Prof. W. R. Johnson observed that his estimate was based upon too high a cost for the zinc, and that 10 cents would be a nearer estimate. In either case, a very great advance is made upon all previous experiments.

Prof. Page also observed, that the cost of electro-magnetic power was not to be reckoned in this comparison by the mere cost of zinc, nor the cost of steam by the pounds of coal consumed. The cost of human life, the sacrifice of millions of property, and risk of many millions more, and all the contingent advantages and disadvantages were to taken into account.

With regard to his mode of measuring the power of the engine, Prof. Page explained as follows after drawing a diagram of the fly-wheel. The brake was loaded to 620 lbs. The power required to barely keep the engine in motion under this load was 126 lbs. The full power being on, the engine made eighty revolutions per minute under this load. The circumference of the wheel being about four feet, it was easy for any one to compute the horse power from these data.

It would seem very desirable that the investigation thus begun, and so far successfully conducted, should be carried at least beyond *an uncertain issue*, and that *every important point* should be settled, and particularly that of its availability on an extensive scale. The power is peculiarly fitted for purposes of navigation, if it can be made subservient; and a trial upon a scale of one

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* The following notice of Prof. Page's experiments is from the Daily National Intelligencer of September 11.

Since the first announcement by Prof. Page of the results of his discoveries, I have seen in several public journals accounts of inventions for the same purpose, by other persons, and in most of them claims to novelty and great superiority. I had some curiosity to refer to Professor P. an article of this kind, from a late number of the St. Louis Republican, in which it was stated that Mr. Bland, of that city, had a new invention, "far in advance," as was shown by calculation, "of that adopted by Professor Page." On making the reference, my attention was called to an article in the 36th volume of Silliman's Journal, page 352, published in 1839, in which Professor Page had explained and figured an electro-magnetic engine, exactly like Mr. Bland's, and which plan, I was informed, was abandoned more than ten years ago.

The fact is, Dr. Page's method is peculiar and entirely new, and distinct from every other hitherto tried; and therein lies the source of his success. Instead of going upon beaten tracks, which, though seemingly fair, he was persuaded would not reach the desired end, he marked out an entirely new one. One great difference between his and other plans, as I understand it to be, is this: In all former electro-magnetic machines, the power is made up of a series of impulses, while in this, which he styles an *axial* machine, or engine, the power is uniform and continuous; and it is just as easy to make a reciprocating engine of twenty-four feet stroke as one of two feet, like that already constructed and recently exhibited.

I saw at the laboratory of Dr. Page, a *rotary axial engine*, which he thinks may, in many cases, supersede the reciprocating. It is really a curious machine; and looking at this, and all his wonderful results, it appears as if we had just entered upon a new era in science and art, promising revolutions in social life and business pursuits as miraculous to the people of the day as have been those effected by the steam engine and the magnetic telegraph. * * *

In order to show that there was something like *power*, he loaded down the engine, placed the crank at half stroke, and then a hook over the end of the crank, to which hook was attached a long rope. Three of the strongest men of the party then took hold of the rope, two of them having their feet braced. The three men could not start the engine a hair's breadth. Four of the men then took hold, and they moved the crank two inches, where it stuck fast. The power was then let on, and the engine started, and made a speed of ninety revolutions in a minute. By taking off fourteen pounds from the end of his friction brake the engine made one hundred and ten revolutions per minute. Professor Page stated that this was not testing the power of the engine, but it showed that what four men could but just move through two inches, the engine carried through one-fifth of a mile, and that, too, in one minute. Understand that, from the change in the position of the crank, the power of four men could go no further than the two inches.

Professor Page expects to make a trial upon a railroad soon. He has sufficient power now to make a *demonstration;* but is not satisfied with it. He would be glad to make the first trip with fifteen to twenty horse power. It is, however, in navigation that he expects the greatest benefits from this invention, and I would like to see the project carried out of an engine and magnetic boat [not steam boat] of one hundred horse power. This would settle the question, and enable the hundred horse power seems to be the only mode of arriving at a definite conclusion upon this point. It is obvious that, preliminary to such an undertaking, a great many experiments will be absolutely necessary; and such only as one quite familiar with the difficulties of entering upon an entirely new field of operation can properly appreciate.

ART. XXXII.—*Singular property, and extraordinary size and length of the Secondary Spark;* by Prof. CHAS. G. PAGE, M.D., Washington, D. C.

IN experimenting with my great magnet a new property of the secondary spark has been discovered and some very interesting facts elicited. I will premise that the helix nearly a foot in diameter each way, when charged by the battery, draws up within it in a vertical position a huge bar of iron weighing 300 pounds, through a distance of ten inches, presenting by far the most powerful magnet ever known. When the circuit with the helix is suddenly broken a secondary spark is produced, *eight inches in length.*

The most interesting feature of this spark is the modification of its form and sound by the action of magnetism. When the spark is produced at a distance from the magnet, it is readily elongated to six or eight inches, and I presume might be obtained a foot or more in length if the wires were separated with the velocity of a cannon ball, as suggested by my friend, Mr. Lane. In this case there is little or no noise made by the spark, but as the spark is produced nearer to the magnetic pole the sound increases until at last when close to the pole each spark makes a report as loud as a pistol. The spark also diminishes in length and is spread out as large as the palm of the hand. There is an effect here somewhat analogous to that produced by a magnet upon the arc of flame between charcoal points. I must reserve further remarks for another number of the American Journal.

Washington, D. C., Aug. 27, 1850.

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world to enter upon the benefits of the discovery, or satisfy mankind that the power cannot be made available for "locomotion or navigation;" and thus arrest the further sacrifice of mind and means, in endeavors to find that which (if it cannot be secured by the present plan) does not probably exist. A point has been arrived at in this investigation which indicates, to use the language of Professor Page, in his late report sent to Congress, the importance of carrying the thing "beyond an uncertain issue." I have no doubt of the applicability and economy (especially if we count the risks and value of human life) of this power for the purposes contemplated by Congress in providing for the experiments; but the world may not yet be satisfied, and many experiments have still to be made, and much money expended before the invention will be really available. Fulton's steamboat would bear but a sorry comparison with those of modern construction; yet who will say that Fulton's limited success should have been the signal for suspending all efforts to use steam as a propelling power for ships, or that to his zeal and intelligence we are not indebted for the introduction of what we now enjoy in the way of steam navigation? H.

Art. XXXIII.—*On Rutile and Chlorite in Quartz;* by O. P. Hubbard, M.D., Prof. Chem., Min. and Geol., Dart. Coll., N. H.

From the Proceedings of the American Association for the Advancement of Science, New Haven, 1850.

Specimens of rutile in quartz have for twenty years past, been found in boulders in several towns in the vicinity of Dartmouth College, none of which have ever been traced to their sources. Localities have been mentioned, but none have furnished specimens resembling these boulders, excepting a single one. This locality was opened two years since at Waterbury, Vt., on the Central Railroad. It was described by Mr. Alger in the Proceedings of the American Association for 1849, and also in the present volume of this Journal, page 14.

In a cut of sixty feet perpendicular through solid talcose slate, and thirty feet from the surface, a vein or pocket of quartz was met, and a considerable number of specimens containing rutile were obtained. The locality is now exhausted. From its position, it never could have furnished the scattered masses heretofore known, and we have yet to discover their origin.

Some of the specimens from this region have comparatively but little beauty; the rutile is in very fine capillary crystals of dark color, two or three inches in length, and the quartz is of inferior quality. But others are exceedingly fine, both in the richness of the quartz and the abundant long needles of the rutile.

There are *three* known American specimens of a remarkable character, one of which is from this Waterbury locality. The other two were found as boulders and are even of superior quality.

One of these has been in the Cabinet of Dr. J. R. Chilton, New York City, for many years, and is reported to have been found in Northern New England. It has the rutile in long acicular crystals and one series of prisms united into a crystal a quarter of an inch wide.

The other is a mass in the writer's cabinet, described by Mr. Alger as "the finest specimen of this mineral found in the United States." It was picked up in this region nearly twenty years ago, but in what town is not known. Specimens from Rochester and Bethel, Vt,, resemble it more than any others.

It is about six inches long and three inches in its other dimensions, being of irregular shape, and only a fragment of a larger mass. Two sides have been cut and polished by the lapidary, one retains its polished plane boulder surface, and the remaining part of the exterior is irregular, presenting a conchoidal fractured surface. There are indications of smooth cleavage faces in different parts inclined to each other.

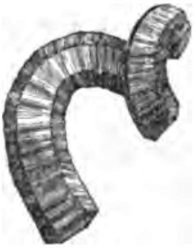
The quartz in mass is transparent and slightly smoky—while the slices cut off are almost colorless. It is questionable whether the color is proper to the quartz, or occasioned by the reflection from the rutile crystals. Mr. Alger finds almost no rutile in the *white* quartz crystals from Waterbury, "while the colored varieties abound with it," and probably, he suggests, owe their color to it.

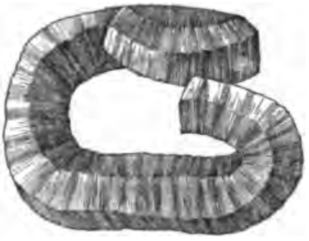
The rutile crystals are from the size of the finest hair and almost invisible, up to a twelfth of an inch in diameter and five inches long; they are uniformly distributed through the quartz, and intersect and cross each other in all directions. There is no radiation from a centre, but in many instances the crystals have one or more large graceful curves, and sometimes two in opposite directions, and some are bent at an angle either right or oblique. Many are broken at the surface of the quartz, while others are wholly included in it, terminating in a single plane or tapering to a point.

They are all of a uniform bright reddish brown color, and of the lustre of polished copper. Where the ends are seen on the polished faces they have the color and lustre of polished steel.

In numerous cases the surface of the crystals is covered here and there with a brilliant, silver white mineral, sometimes limited to the lateral edges, and again investing parts of the prism at intervals, or with frequent interruptions, giving it the appearance of being made up of numerous short white and brown prisms, the form remaining unchanged. In some cases this mineral occurs like a thin disk, through the centre of which the rutile appears to penetrate. I have not been able to determine with certainty the nature of this mineral, and can only conjecture that it is the same with the curved crystals described below.

In the writer's specimen, as in those described by Mr. Alger, there are numerous vermiform, tortuous and convoluted crystals. By transmitted light, they are sometimes of the color of copper, though faintly so, or of a bronze yellow, or of greenish and yellow shades or even very dark, and by direct light they are almost black. These crystals are regular hexagonal prisms, transversely finely striated, and appear to be made up of thin plates of slightly varying size, giving the crystals a varying diameter. They occur either singly or in groups of several laterally joined, and united in all their convolutions, and having a single terminal plane, highly lustrous, which often presents a silver white color. The above figures, en-





larged views of two of them, give a perfect idea of the originals, the prismatic form of which is obvious to the eye and perfectly distinct with a glass. If we judge from the figures in Mr. Alger's paper in this volume, (p. 14,) the prismatic character of his crystals is much less striking.

Mr. Alger has described the mineral in his specimens, as *mica.* I have been able to obtain only a very small portion of the mineral from one or two protruding curves on my specimen. It readily cleaves parallel to the terminal plane, is apparently softer than mica, and is easily reduced by the pressure of a knife on white paper, into a fine, coherent powder, of a greenish tint. It has no elasticity, and before the blowpipe gives off an abundance of water. From these decided characters, and the rarity of such an association of mica, and the quite frequent one of chlorite and quartz, it seems altogether probable that this mineral is *chlorite.*

If these several minerals were at one time in solution in the fluid quartz, they must have crystallized previous to it. The rutile prisms are so straight or so gracefully curved and bent, that they would seem to have experienced but slight resistance. They intersect and cross each other, and pass *through the loops in the chlorite* crystals or touch them on the outside, and they probably crystallized first. Around most of these convolutions of *chlorite* there is a burr, or a minute spot of imperfectly radiating fractures, occasionally iridescent, which suggests that they were formed before the solidification of the quartz, and that they had occasioned some pressure or disturbance and a slight fracture. But as the chlorite uniformly, and the rutile in very many cases, must have been without any attachment, the density of the fluid quartz to have sustained them was probably great.

On removal of the rutile and chlorite from the gangue the vertical striæ of the former and the transverse striæ of the latter are found figured on the quartz, making it certain that the latter was last solidified.

There must be somewhere in this region north, a rich deposit, for which mineralogists will earnestly seek, until it is found and its treasures are transferred to their cabinets.

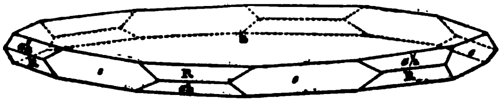
Art. XXXIV.—*Occurrence of Crystallized Oxyd of Chromium in furnaces for the manufacture of Chromate of Potash;* by W. P. Blake.

Read before the American Association for the Advancement of Science, New Haven, August, 1850.

Crystals of the sesquioxyd of chromium have been obtained in small quantities by Wöhler, by passing the vapor of chlorochromic acid through a tube heated to redness.

The crystals which I have examined with the following results, were obtained from a furnace which had been long in operation for the production of chromate of potassa from the mineral chromic iron. A portion of the furnace having been taken down for repairs, I found small but exceedingly brilliant crystals lining the cracks and fissures between the fire bricks and disseminated throughout their substance. They resembled crystals of specular iron, but a blowpipe examination and qualitative analysis proved them to be the sesquioxyd of chromium.

The crystals are of the hexagonal system, and are flat 6 or 12-sided tables or scales, one of which is represented in the annexed figure. The breadth of the largest is 1½ lines, but they are seldom over a line broad, and usually much smaller. In some of the specimens the crystals are grouped in rosettes of great beauty. The following angles were obtained with the reflective goniometer:



R : a $=121^\circ\,55'$ (mean of 14 measurements.)
R : $a\frac{1}{2}=96^\circ\,45'$ (mean of 6 measurements.)
a : $a\frac{1}{2}=141^\circ\,38'\,24''$ (mean of 5 measurements.)

Calculating from a : R, the angle a : $a\frac{1}{2}=141^\circ\,15'$, and R : $a\frac{1}{2}=96^\circ\,50'$; and as the plane $a\frac{1}{2}$ is exceedingly small, this result is more probably correct than that given above from measurement.

The angle a : R gives for the angle of the rhombohedron 85° 22′, which is but little less than that given for specular iron. The axis $=1{\cdot}39045$. The crystal according to Naumann's notation has the descriptive expression, $0R$, R, $-\frac{1}{2}R$, R^∞.

The crystals have the hardness of sapphire, equal to 9 on the scale of Mohs. Lustre metallic. Color black; opaque except in thin plates, which are green by transmitted light. The powder of the crystals is dark green.

The specimens were taken from and between the bricks which had constituted the floor of the furnace. The furnace had been in operation for more than a year, and kept at a temperature above redness. As it needed repairs, the fires were drawn, it was allowed to cool undisturbed for ten days, and when the bricks were taken out they were still too hot to be taken in the hand.

The mass of the bricks and the portions on which the sesquioxyd has crystallized, is charged with soluble yellow chromate of potash, and in many or all of the specimens the green color of the uncrystallized oxyd can be seen.

My frequent daily examinations of the furnaces in operation made me familiar with the condition in which the contents were at different times, and considering the facts before stated, I account for the production of the crystals in the following way.

When the furnace, newly constructed or lined with fire-brick, is fired and charged with alkali and chrome ore, much of the fused chromate of potash formed, is absorbed by the porous bricks, and I observed that it had penetrated through three or four courses of bricks and mortar.

After the furnace has been long in operation the bricks become saturated, and vitrified, to a certain depth; and the floor and sides of the furnace become incrusted with a vitreous coating, which is constantly increasing. The parts more remote from the fire are consequently better protected from changes and variations of temperature, and are exempt from the inroads of more fused material.

The chromate of potash is thus kept for a long time at a uniform high temperature, and gradually losing its potash from volatilization, the chromic acid ($\dddot{\mathrm{Cr}}$) in combination with it loses oxygen, becomes sesquioxyd ($\dddot{\mathrm{\rlap{-}Cr}}$) and crystallizes.

Art. XXXV.—*Memoir on Emery;* by J. Lawrence Smith, M.D.—First part—*On the Geology and Mineralogy of Emery, from observations made in Asia Minor.*

Read before the Academy of Sciences of the French Institute, July 15th, 1850, and communicated by the author for this Journal.

Of all the mineral substances employed in the arts, few have offered so little opportunity for geological examination as emery, and consequently our knowledge of it in this particular is very limited.

Aware of the importance of the study of this substance *in situ*, both in a scientific and practical point of view, I did not lose the opportunity afforded by my late position under the Turkish government to develop certain facts that came under my notice the latter part of the year 1846. Prior to that period, emery (which term is here used as in the arts to express that mixed granular corundum employed for abrasion) although known to exist in many places in greater or less abundance, was supplied to the arts almost entirely from the island of Naxos in the Grecian Archipelago; so true is this, that the proprietors of the mines in that island controlled completely the price of this mineral. The emery from Naxos frequently went under the name of Smyrna emery, from the fact of its coming to us from that port, where it is originally carried from the island for future exportation.

Prior to 1846, the existence of emery was not remarked in Asia Minor or any of the contiguous islands except that of Samos, which fact is alluded to in Tournefort's travels in the seventeenth century. In the latter part of 1846, I arrived in Smyrna, and was shown specimens which I recognized as emery that came from a place about twenty miles north of Smyrna; they had been first discovered through the agency of a knife grinder of the country, who had been in the habit of using it to charge his wheels with. The importance of this circumstance to the Turkish government as well as to the arts (emery being at that time sold at a most exhorbitant price) induced me to return to Smyrna in the early part of 1847, for the purpose of examining the supposed locality of this mineral. On this second visit other localities were made know to me that an English merchant by the name of Healy had succeeded in bringing to light.

The first locality towards which I directed my examination was that of *Gumuch-dagh*, a mountain about twelve miles east of the ruins of *Ephesus*. Before, however, arriving there, I discovered this mineral imbedded in a calcareous rock in a valley twenty miles south of Smyrna, called *Allahman-Bourgs;* the position not being very favorable for the study of the geology of this substance, my route was continued to the place originally fixed upon. Obtaining guides at the village of *Gumuch*, I commenced the examination of the mountain, which is composed of bluish marble resting on mica slate and gneiss. On the very summit of the mountain, the emery was found scattered about and projecting above the surface of the soil. After examining the extent of the formation and satisfying myself that it was there *in situ*, I returned to Constantinople, and made a report to the Ottoman government. Although I gave no notice to the scientific world of the result of my examination, the editor of the *Journal de Constantinople* inserted a small note in his journal in May, 1847, to the following effect—

"It is some time since M. Lawrence Smith, American Mineralogist, discovered at Magnesia near to Gumuch-Kuey an emery mine, of which he brought specimens to Constantinople. The government have sent to the place a commission composed of M. Smith and some of the officers of the imperial powder works, to examine thoroughly into the importance of this mine, and according to the report that will be made the government will decide on the steps to be taken with reference to it, &c."

This circumstance, unimportant in itself, has subsequently become of great value to secure to me the priority of the discovery and examination of emery *in situ* in Asia Minor;* and also to show that I have been instrumental in the development which has been subsequently given to this emery in a commercial point of view. Since the first discovery other localities have been ascertained by me, all of which will be alluded to in this memoir.

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* See Am. Jour. Sci., 2nd ser., vol. vii, 288.

Localities of Emery in Asia Minor and the neighboring islands.

Gumuch-dagh.—In going from Ephesus east to *Gouzel-Hissar* (the ancient *Tralles*) we pass by the ruins of the ancient city of Magnes on the Miandre and near to this latter is a beautiful valley, celebrated for its figs, in which is situated the village of *Gumuch* at the foot of a mountain bearing the same name. It was here that the emery formation was first examined. All the rocks of the surrounding country appear to belong to the old series; the limestone is entirely devoid of fossils and metamorphic in its character; it rests on the older schists of which mica schist appears the most abundant, and this again farther to the north was traced in contact with gneiss. The limestone is of a light blue passing into a coarse grained marble; and on the south side, the rock by its decay leaves in many places precipices of considerable elevation, that add much to the picturesque appearance of the region.

The emery is found in different places in the *Gumuch* mountain; the place, however, to which it is traced in greatest abundance, is on a part of the summit about three miles from the village of Gumuch, and some fifteen hundred or two thousand feet above the level of the valley; it overlooks the magnificent plain of the Miandre, whose curiously tortuous course is seen as if traced on a map. The emery lies scattered on the surface in the greatest profusion, in angular fragments of a dark color, and large masses of several tons weight are seen projecting above the surface; in penetrating the soil, the emery is found imbedded in it and a little farther down it is come to in the rock. In fact by breaking the marble that projects above the surface at this spot we are sure to find nodules of the mineral.

Sometimes the emery forms almost a solid mass several yards in length and breadth. One of these places, opened for the purpose of exploring, is about ten or twelve yards square and all the rock taken out is emery; the spaces between the blocks are filled with an earth highly charged with oxyd of iron. In some places the masses are consolidated by carbonate of lime of infiltration, which must not be confounded with the emery in its original gangue (the marble) in which it is found in nodules sometimes round and at other times fissured so as to represent angular fragments. In no place does it present anything like a vein, nor has it signs of stratification. The largest mass at this locality that I saw unbroken must weigh from thirty to forty tons.

Attached to this mineral, more especially in the fissures and on the surface, are several minerals that will be alluded to hereafter.

Kulah.—This locality of emery is the second in importance in Asia Minor, it is a town situated about a hundred and fifty miles from *Gumuch* and twenty miles from the ancient city of Philadelphia (one of the seven churches). It is near the river Hermes, and on that interesting volcanic district of Asia called *Catacecaumene* or the burnt country, resembling in many respects the volcanic region of Auvergne. The rocks forming the base of this region are of the older metamorphic series, covered to a greater or less depth by lava of different volcanic periods, which has flowed from the numerous craters that form the prominent feature of this region. The most common rocks in the mountain ranges about Kulah are white granular limestone, mica slate, hornblende schist, gneiss and granite; the last four are seen more conspicuously in the mountain two or three miles to the south, which have not been subjected to volcanic action; the limestone overlies these rocks.

Before arriving at the place where I examined the emery, (about two miles to the northeast of Kulah,) an outcropping of gneiss was seen and subjected to the closest scrutiny, without discovering the slightest trace of corundum; and I will here remark that although I have found several thin layers of mica schist engaged in the marble, in no instance was there any trace of corundum in it.

The marble in this region is very compact, of great hardness and I may also add of great purity. I cannot say whether this hardness is traceable to a greater depth than that to which it has felt the influence of the superimposed lava. Here again the emery was found on the surface, but not in such abundance as at *Gumuch-dagh*, and moreover the soil is not as deep as in the latter place. The emery as seen in the marble at Kulah is capable of being studied with the greatest satisfaction, particularly as two or three places in the rock have been quarried.

Adula.—Not far from this town which is about twelve or fifteen miles east of Kulah, I have also discovered emery, only, however, in very small quantity.

Manser.—About twenty-four miles north of Smyrna, emery is found in small quantity in the soil. In this as well as in the former place, white granular limestone is found.

Island of Nicaria, Grecian Archipelago.—I have also been able to examine thoroughly the emery of this island, which promises to be of importance to the arts. It is only within about twelve months that it has been brought to light. The mineral of this locality presents some peculiar features which will be alluded to hereafter. The geology is the same as that of the other localities already alluded to, namely, when found in contact with the rock it is always with limestone.

Island of Samos.—This locality has furnished me with only a few nodules imbedded in the soil with a little calcareous rock attached to the surface.

Island of Naxos.—This old and well known locality is here alluded to, simply because it has furnished me with specimens, the examination of which forms a part of this memoir. It is found in large blocks mixed with a red soil and also imbedded in white marble. It is taken principally from the north and east side of the island—the best comes from *Vothrie*, nine miles from the shore, and is embarked at *Sulionos*. Another good locality is at *Apperanthos*, seven miles from the shore, and it is embarked at a small port called Moutzona. In the south of the island it is found near *Yasso*. It is in such abundance on this island, that notwithstanding the immense quantity carried off it is not yet found necessary to quarry it from the rock.

Conclusions with reference to the Geology of Emery.

The localities at Gumuch-dagh and Kulah are those which afforded me the best means of studying the geology of emery, although in every instance I have found it associated with the old limestone overlying mica slate, gneiss, &c.

It is imbedded either in the earth that covers the limestone or in the rock itself; and exists in masses from the size of a pea to that of several tons weight, generally angular, sometimes rounded, and when in the latter form they do not appear to have become so by attrition.

The masses in the soil possess but little interest for the geologist, as they may have been left there by the decomposition of the rock, or been transported from other positions; still, the latter is difficult of supposition, in reference to what is found at *Gumuch-dagh*, for here it is only on the summit and not on the sides of the mountain that the emery has been traced. But having had the means of studying the emery and rock in contact, I have come to the firm conclusion, that the *emery has been formed and consolidated in the limestone in which it is found*, and that it has not been detached from older rocks as granite, gneiss, &c., and lodged in the limestone at the period of its formation. My reasons for so thinking are the following—

1st. In no instance could the closest investigation of the older rocks of these localities, that are below the limestone, furnish the slightest indication of the existence of emery there; and moreover the masses of emery in the limestone never had fragments of another rock attached to them. A few thin layers of mica slate were found in the limestone, but they were not in contact with the emery, nor contained any traces of corundum. I dwell thus much on this point, because in my specimens the calcareous rock in connection with the emery is under two forms; that of the original rock, and that formed by the infiltration of calcareous water in the fissures which exist near the surface.

2d. The limestone immediately in contact with the emery differs almost invariably in color and composition from the mass of the rock; and at *Kulah*, where the marble forming the rock is remarkably pure (as evinced by analysis), the part in contact with the emery is of a dark yellow color resembling spathic iron, and contains a large portion of alumina and oxyd of iron. The thickness of this interposing coat between the emery and the marble is variable; but what is certain, it passes gradually into white marble, so that their crystalline structures run into each other, showing that they are one and the same rock. Had the masses of emery been broken from an older rock and imbedded in the marble at its formation, there is no reason why the contact should not always be direct and immediate without this transition from ferro-aluminous limestone to pure marble. What we see is just what should be expected in ferruginous and aluminous minerals forming and separating themselves from a limestone not yet consolidated.

This kind of separation between the emery and the marble has been highly useful in the facility that it has indirectly afforded for exploring this mineral. It has been stated that at all the localities under consideration, but principally at Gumuch and Naxos, the emery exists in great abundance detached from the rock in a red earth; now this earth is simply the result of the decomposition of this heterogeneous calcareous envelope, which from its nature is easy of disaggregation by the influence of atmospheric agents. Had the emery been in immediate contact with the marble we could hardly have expected this spontaneous separation in so great a quantity.

I have in some instances seen small nodules of emery in small cavities in the rock but perfectly detached.

3d. The immense mass alluded to as covering several square yards of surface is another evidence of the emery having been formed in the limestone; for this mass does not consist of a single piece, but of a number of different sizes, not lying together irregularly, but with their contiguous surfaces more or less parallel, although removed a little distance from each other; in fact, it is just what we would expect in a large mass that for some cause or other had been fissured in various directions.

4th. Yet another circumstance to be remarked in connection with this part of the subject, is, that in the examination of the surface of contact between the emery and the rock, we do not always see it marked by a distinct outline; but the minerals constituting the emery as well as those associated with it, are more or less disseminated in the limestone at the point of contact; the value of this argument is better understood on examining the specimens in my possession.

Enough having been said to prove that the emery under consideration was formed within the limestone in which it is found, I will allude to the process of segregation which has given rise to this formation.

It would appear that the substances eliminated from the calcareous rock, were silica, alumina, and oxyd of iron, and that these three in the exercise of homogeneous and chemical attractions have given rise to the minerals which constitute and are associated with emery. In my collection, there is a specimen exhibiting this fact in a remarkable manner. It is a nodule, showing emery in the center, with two concentric layers, the inner of *chloritoid* and the outer of *emerylite;* the latter was in contact with the limestone.

Emery—mixture of corundum (alumina a little hydrated) and oxyd of iron.

Chloritoid—silica 24, alumina 40, oxyd of iron 28, water 7.
Emerylite— " 30, " 50, lime 13, water 5.

It is seen that in commencing from the external surface, in which direction we must regard the consolidation of the nodule, that the larger portion of silica eliminated has combined with a large portion of alumina and some lime to form a peculiar mineral; next, the remainder of the silica combines with an additional quantity of alumina and considerable oxyd of iron to form another mineral; and finally the remaining alumina and oxyd of iron crystallize separately. Facts of this kind in geology are not unfrequent, but they are always highly interesting and worthy of remark.

In concluding the geological considerations of emery with reference to the localities in Asia Minor and the neighboring islands, I would remark, that at some future time when the observations become extended, it will doubtless be found that the emery forms the geognostic mark of extensive calcareous formations in that part of the world, just as the flints do in the chalk of Europe.

Mineralogical position of Emery.

Emery has been considered by some as corundum, others suppose it represented by some rock or other, not always the same, in which corundum is disseminated in greater or less quantity; others again consider it a mixture of corundum and oxyd of iron. I am of opinion that the latter is the most correct manner of regarding this substance.

Emery properly speaking is not a simple mineral, but a mechanical mixture of granular corundum and oxyd of iron in which the former usually predominates. It has not the aspect of corundum disseminated in a rock, for it is found in distinct masses of different dimensions and of great hardness; and when broken giving way in the directions of fissures, which exist commonly in the mass. Most frequently there is no other evidence of the presence of corundum in emery but its hardness. The oxyd of iron present is always under the form of magnetic oxyd more or less mixed with oligiste; sometimes it is titaniferous. There are other minerals associated with the emery, all of which will be described hereafter.

The aspect of this substance differs more than is supposed, for until lately, the emery brought from Naxos has been the criterion by which to judge others. The localities that I have discovered furnish me with specimens showing considerable difference not only as regards color but also in the structure.

The *Naxos emery* is of a dark grey with a mottled surface, and with small points of a micaceous mineral disseminated in the mass. It frequently contains bluish specks or streaks which are easily recognized as being pure corundum.

The *Gumuch-dagh emery* is commonly of a fine grain and dark blue bordering on black, not unlike certain varieties of magnetic iron ores. With this variety we frequently find pieces of corundum of some size. The interior of the mass is tolerably free from the micaceous specks found in that of Naxos.

The *Kulah emery* is usually coarse grained, and much darker than that of Gumuch-dagh, its external surface resembling sometimes that of chromate of iron.

The *Nicaria emery* in many instances presents a schistose or lamellated structure to a very remarkable degree, so much so that certain specimens might pass for gneiss. The color is dark blue and somewhat mottled like that of Naxos. There is also much that is quite compact found in the same locality. The lamellated variety contains an abundance of a micaceous mineral, which in this instance appears to have determined its structure.

The *Samos emery*, as yet found only in small quantities, and in the form of nodules, is uniformly of a dark blue color, sometimes of a coarse grained and at other times of a fine grained structure not unlike certain varieties of very compact blue limestone.

Fracture.—The fracture of emery is tolerably regular, and the surface exposed is granular of an adamantine aspect; it is exceedingly difficult to break when not traversed by fissures or not of a lamellated structure as much of that from Nicaria. When reduced to powder it varies in color from that of a dark grey to black. The color of its powder affords no indication of its commercial value.

The powder examined under the microscope shows the distinct existence of the two minerals, corundum and oxyd of iron, which appear inseparable as the smallest fragment contains the two together.

Magnetism.—As it is natural to suppose all specimens of emery affect more or less the magnetic needle; in some the magnetism is barely perceptible, in others it amounts to strong polarity.

Odor.—Emery when moistened always affords a very strong argillaceous odor; even the most compact varieties.

Specific gravity.—The different varieties do not vary much in their specific gravity, it being always in the neighborhood of 4. The specific gravity of various specimens will be given on a following page.

Hardness.—The hardness of emery is its most important property, as to it is due the value of this substance in the arts. For this reason I have devoted much time and attention to the determination of it. In a mineralogical sense its hardness is not difficult to determine; for if we try different varieties of emery by scratching agate or other hard substance, the effect will naturally be very nearly the same; for in every case, it will be some point of corundum that has produced the scratch. If, however, we happen not to rub a point of corundum against the agate no effect will be produced on the latter, but the emery will yield. As this method leads to no practical result, I have sought out another, which may be properly called one for determining the *effective hardness of emery and corundum*, and is as follows.

Fragments are broken from the piece to be examined, and crushed in a diamond mortar with two or three blows of a hammer, then thrown into a sieve, (the one employed had 400 holes to the square centimetre,) the portion passing through is collected, and that remaining on the sieve is again placed in the mortar and two or three blows given, then thrown into the sieve; the operation is repeated until all the emery has passed through the sieve. The object of giving but two or three blows at a time is to avoid crushing any of the emery to too fine a powder.

Thus pulverized it is intimately mixed and a certain portion of it is weighed, (as I operated with a balance sensible to a milligramme, the quantity used never exceeded a gramme.) To test the effective hardness of this, a circular piece of glass about four inches in diameter and a small agate mortar are used. The glass is first weighed and placed on a piece of glazed paper; the pulverized emery is then thrown on it little by little, at each time rubbing it against the glass with the bottom of the agate mortar.

The emery is brushed off the glass from time to time with a feather, and when all the emery has been made to pass once over the glass, it is collected from the paper and made to pass through the same operation which is repeated three or four times. The glass is then weighed, after which it is subjected to the same operation as before, the emery being by this time reduced to an impalpable powder. This series of operations is continued until by repeated weighing the loss sustained by the glass is reduced to a few milligrammes. The total loss in the glass is then noted, and when all the specimens of emery are submitted to this operation under the same circumstances, we get an exact idea of their relative hardness.

The blue sapphire of Ceylon was pulverized and experimented with in this way; it furnished me with a unit of comparison by which to compare the results obtained. This operation is long but certain, and for the harder varieties of emery it is necessary to repeat the rubbing six or seven times and it requires nearly two hours for completion.

The results that I have obtained are interesting and have furnished me with the means of forming conclusions that I could not have otherwise come at.

Glass and agate have not been chosen for this experiment without a certain object, as experiments were first made with two pieces of agate, with two pieces of glass, and with metal and glass. The agates were found too hard, as they crushed the emery without producing hardly any abrasive effect; the others were found not to crush the emery sufficiently, making the experiment tedious and long. With the glass and agate we have a hard substance which crushes the emery, and in a certain space of time reduces it to such an impalpable state that it has no longer any sensible effect on the glass, and on the other hand, the glass is soft enough to lose during this time sufficient of its substance to allow of accurate comparative results. In the employment of this method in the arts, it would not be necessary to go to the sapphire for a standard of comparison; any good emery would answer the purpose quite as well.

It must be understood that this method of coming at the abrasive effects of emery does not furnish the mineralogical hardness of this substance, by which we understand the hardness of any individual particle, as evinced by its effect on a substance of less hardness, without regard to the molecular structure of the mineral. Two minerals possessing the same hardness but differing in structure, one being friable, and the other resisting, will be found very different in their abrasive effects; for instance, break a piece of quartz in two, subject one of the pieces to a white heat, and after cooling, compare the two by rubbing the point against some hard substance; both will be found to scratch equally well: then try the two in a state of powder, by rubbing them between two pieces of glass that have been weighed, and the difference of their abrasive effects will be found very great; because, the one subjected to the fire is exceedingly friable, and becomes readily crushed to an impalpable powder. This fact is eminently true with reference to emery, many specimens of which containing the same amount of corundum differ somewhat in their *effective* *hardness* owing to the more or less compact structure of the corundum.

By the method with the agate and glass I have found the best emery capable of wearing away about one-half its weight of the glass (that used was the common French window glass). The sapphire under the same circumstances wears away more than four-fifths of its weight. A tabular view of the results will be given a little farther on.

Chemical composition of Emery.

This substance consisting of a mixture of corundum and oxyd of iron in various proportions, it is easy to see what its composition must be. Yet the chemical examination of this mineral taken in connection with other properties is not devoid of interest.

For the purpose of analysis, the emery was reduced to a state of powder, in the manner alluded to in speaking of its hardness, with a diamond mortar and sieve. This powder was dried for twenty-four hours over sulphuric acid; a gramme was then weighed in a small platinum crucible of about one-fourth of a cubic inch in capacity, fitted with a cover that adapted itself well to it; this small crucible was placed in another of earth, and the space between the two filled with pulverized quartz which also covered the smaller one to the depth of half an inch. Common sand was not used, because during the heating some particles might adhere to the platinum crucible by a semifusion; nor was powdered charcoal employed because it protected the mineral no better than the pulverized quartz from contact with the air, at the same time a little risk was run in decomposing a small amount of the iron.

Thus arranged the crucibles were heated to a bright red for from thirty minutes to one hour. After cooling, the platinum crucible was carefully withdrawn and weighed. The loss furnished me with the amount of water in the emery.

It requires a continued red heat to drive out all the water, a circumstance which is true for a number of minerals, particularly for those containing a large amount of alumina as diaspore and the micas which will be spoken of in this paper.

The powder, of which the water has been estimated, was next submitted to levigation in a large agate mortar placed on a surface of glazed paper; and when completed, it was carefully detached from the mortar, placed in a platinum capsule, heated gently to drive off any hygrometric moisture and weighed; the increase of weight furnished the amount of silica taken from the mortar.

The levigation of one gramme was accomplished in two operations, each requiring about twenty minutes; and by using a mortar of convenient size and the extremity of a feather or a small brush, it is possible to lose but an insensible quantity of the mineral and to estimate with sufficient precision the amount of silica abraded from the mortar.

Another method by which I accomplished the levigation in some of the analyses, was in a steel mortar of the same form as the agate mortar; and when completed the powder was placed in a glass with nitric acid diluted with thirty times its weight of water and left in it for one hour agitating it occasionally. The iron taken from the mortar was dissolved, and no part of the mineral attached. The next thing was to filter and continue the analysis with the substance thus freed from the iron of the mortar, without any second weighing.

Of these two methods I preferred to employ the first for the emery, as it is more expeditious and almost if not quite as exact as the second. There are, however, occasions in which the steel mortar should be resorted to.

The substance once reduced to an impalpable powder, it was necessary to render it *completely* soluble, and my researches to arrive at this were long and tedious. In trying the various known methods the most successful was found to be that with a mixture of carbonate of soda and caustic soda heated to whiteness for one hour; nevertheless I could not obtain a complete decomposition. The decomposition might probably be completed if the levigation was made more thoroughly, but it is easy to understand, that with a large number of analyses of the same substance to make, it was a desideratum on my part not to consume the best part of a day in the levigation of a single gramme; particular, as I did not wish to confide this operation to another, as much care was required to lose nothing during the levigation. Mixed with carbonate of baryta and heated in a forge, the decomposition of the mineral was far from being complete; the same may be said for the treatment with the caustic alkalies in a silver crucible.

The bisulphate of potash decomposes it almost entirely by a single operation, but unfortunately, a double salt of potash and alumina is formed which is almost insoluble in water or in the acids, and it is only by a solution of potash that it is first decomposed and afterwards redissolved. I will not stop to detail all the disadvantages attending this method, but will at once speak of the method which gave me very easily the most accurate results.

It is by means of the bisulphate of soda that all my analyses of emery, of corundum, and of several aluminates were made. I believe that I am the first who has shown the great advantage of using this double salt in the decomposition of certain substances insoluble in the acids; and very probably it will replace in most cases the use of the bisulphate of potash in analytical chemistry. At present, all the advantages that may arise from the substitution of the soda for the potash salt cannot be mentioned; all that I will say is, that the former in giving a decomposition at least as complete as the latter, furnishes a melted mass quite soluble in water, and in the future operations of the analyses there is no embarrassment from a deposit of alum.

The bisulphate of soda was prepared by adding an excess of pure sulphuric acid to the pure carbonate or neutral sulphate of soda and heating it in a capsule until all the water had been expelled and sufficient of the acid to allow of the mass becoming solid on cooling. That obtained in commerce is not sufficiently pure.

The pulverized emery is placed in a large platinum crucible with six or eight times its weight of bisulphate of soda, and the mixture is heated over a lamp in the same manner and with the same precautions as are employed when using the bisulphate of potash. From fifteen to thirty minutes suffice for the operation. The mass is allowed to cool, and water with a few drops of sulphuric acid are added to it and the whole heated, when it soon dissolves with the exception of a little silica, that renders the solution milky, and a small quantity of undecomposed mineral, that is readily detected by rubbing a glass rod against the bottom of the capsule. The liquid is now filtered, and the filter is washed once with a little water; then with its contents it is placed in a platinum crucible, burnt completely, and the residue is heated with a little bisulphate of soda, which completes the decomposition: and when treated with water and a drop or two of sulphuric acid all except the silica is dissolved. The liquid which passes the filter in this case is added to the first and the analysis continued. The silica obtained is diminished by the quantity taken up from the mortar in order to arrive at what is actually contained in the mineral. The filtered solution is heated with a little nitric acid to convert all the protoxyd of iron into peroxyd, then treated with an excess of caustic soda and a little carbonate of the same alkali; this redissolves the alumina first precipitated and thus separates it from the oxyd of iron and a trace of lime. The iron and lime are separated in the ordinary way; the alkaline solution of alumina was acidulated and the alumina precipitated with carbonate of ammonia.

Thus analyzed, the emery from different places gave the following results:—

No.	Localities.	Effective hardness. Sapphire 100	Specific gravity.	Chemical composition.					
				Water.	Alumina.	Oxyd of iron.	Lime.	Silica.	Total.
1	Kulah,	57	4·28	1·90	63·50	33·25	0·92	1·61	101·18
2	Samos,	56	3·98	2·10	70·10	22·21	0·62	4·00	99·03
3	Nicaria,	56	3·75	2·53	71·06	20·32	1·40	4·12	99·43
4	Kulah,	53	4·02	2·36	63·00	30·12	0·50	2·36	98·34
5	Gumuch,	47	3·82	3·11	77·82	8·62	1·80	8·13	99·48
6	Naxos,	46	3·75	4·72	68·53	24·10	0·86	3·10	101·31
7	Nicaria,	46	3·74	3·10	75·12	13·06	0·72	6·88	98·88
8	Naxos,	44	3·87	5·47	69·46	19·08	2·81	2·41	99·23
9	Gumuch,	42	4·31	5·62	60·10	33·20	0·48	1·80	101·20
10	Kulah,	40	3·89	2·00	61·05	27·15	1·30	9·63	101·13

I ought to mention that the analysis afforded other substances in small quantities in some of the emeries; as titanic acid, oxyd of manganese, oxyd of zirconium, and sulphur (existing in pyrites); but these substances are unimportant in the composition of emery, and are in such minute quantities, that it is necessary to operate on a considerable quantity of the mineral to obtain satisfactory results concerning them.

The analyses marked 6 and 8 were made by decomposing the emery as it came from the sieve, without pulverization in the agate mortar. It was by accident that it occurred and I was not aware of the neglect until it was fused with the bisulphate of soda, but not wishing to lose the analysis, the operations were continued as in the other cases, only using a little more of the bisulphate in the second decomposition; and somewhat to my surprise, the decomposition was quite as perfect as in the other cases. I had nearly completed all my analyses in the manner detailed, when this fact became known, so that I have but these two cases to report. It will simplify the analysis of corundum if pulverization in a diamond mortar be found sufficient, and I propose examining specially into this question.

The water which was found in the emery comes from the corundum, a fact which will be shown when the analysis of pure corundum is given, which will be in the second part of the memoir. A very minute quantity of what has been estimated as water might be a little oxygen lost by the oligiste which is sometimes found in emery. Those emeries which contain the least water, every thing else alike, are the hardest, as instanced by that from Kulah, notwithstanding the quantity of iron it contains. The silica existing in emery is most often in combination with alumina or the oxyd of iron or with both, for this reason we must not always regard the quantity of alumina as an indication of the quantity of corundum in the emery.

Analogies.

Emery at first sight may be confounded with several ores of iron; as magnetic iron, certain varieties of oligiste and sometimes with chromate of iron; but the fracture of emery is stony which differs from these ores of iron, and besides the surface exposed is of a lighter color. From the numerous observations made, I may set it down as a general rule, that any blackish or dark blue rock of a strong argillaceous smell, that scratches agate easily, with a specific gravity in the neigborhood of 4, is sure to be emery.

The mining of Emery.

The mining of this substance is of the simplest character. The natural decomposition of the rock in which it occurs facilitates its extraction. As has already been mentioned, the rock decomposes into an earth in which the emery is found imbedded. The quantity found under these favorable circumstances is so great that it is rarely necessary to explore the rock. The earth in the neighborhood of the blocks of emery is almost always of a red color, and serves as an indication to those who are in search of the mineral. Sometimes before beginning to excavate, the spots are sounded by an iron rod with a steel point, and when any resistance is met with, the rod is rubbed in contact with the resisting body, and the effect produced on the point enables a practised eye to decide whether it has been done by emery or not.

The blocks which are of a convenient size are transported in their natural state, but most frequently they are required to be broken by means of large hammers; when they resist the hammer, they are subjected to the action of fire for several hours, and on cooling they most commonly yield to blows. It, however, happens sometimes that large masses are abandoned from the impossibility of breaking them into pieces of a convenient size; as the transportation either on camels or horses requires that the pieces do not exceed one hundred pounds.

At Kulah, the quantity of emery detached from the rock was not very considerable, as it had been protected from decomposition by the beds of lava that cover it. Here the marble was quarried to get at the emery which was done in the early part of 1847 with profit, although the transportation from Kulah to Smyrna is over a distance of one hundred and ten miles on the backs of camels. Since the diminution of the price of emery, this mine has been abandoned, for the quarrying into the marble is attended with the greatest difficulty as the tools used for boring, &c., are thrown out of use in a very short time, by the pieces of emery which are encountered at every instant. At present all the emery sent from Asia Minor comes from the mine at *Gumuch-dagh*, twelve miles from the ruins of *Ephesus*.

Commercial consideration of Emery.

The use of emery in the arts is of very ancient date, a fact proved by works on hard stones that could not have been executed except by emery or minerals of that nature. It is very probable that emery coming from the localities which have been mentioned, was used in former ages by the Greeks and Romans. For example, the locality of *Gumuch-dagh* is immediately by the ancient Magnesia on the Meandre, and between Ephesus and Tralles, twelve miles from each of these cities, and the same distance from Tyria; in all of these cities the arts flourished, and none more than that of cutting hard stones, if we are allowed to judge from the specimens of their skill in this art that have come down to us.

Nevertheless, the quantity of emery formerly employed was insignificant in comparison to the quantity now required, more particularly within the last twenty years, since the use of plate glass has been extended. The annual consumption at the present time is about *fifteen hundred tons.*

For various reasons, the island of Naxos furnished for several centuries almost exclusively the emery used in the arts. as much for the facility with which it was obtained as for the uniformity of its quality. The emery exists in very great abundance on this island, and notwithstanding the quantity already extracted there still remain immense deposits of it.

The price of this substance at the end of the last century was from 40 to 50 dollars the ton, and between 1820 and 1835 it was at times even less. About this period, the monopoly of the Naxos emery was purchased from the Greek government by an English merchant, who so regulated the quantity given to commerce that the price gradually rose from 40 to 140 dollars the ton, a price at which it was sold in 1846 and 1847. It was at this time that I commenced examining and developing the emery formations of Asia Minor until then unknown. And after making a report to the Turkish government, the monopoly of the emery of Turkey was sold to a mercantile house in Smyrna, and since then the price of this article has diminished to 50 and 70 dollars the ton according to the quality. I speak of the prices in the English market.

The different mines explored are those of *Naxos* of an ancient date, of *Kulah* commenced in 1847 and now abandoned for these nearer the sea, of *Gumuch-dagh* commenced in 1847 and worked largely, and of *Nicaria* commenced in 1850. From all these different places the emery goes to Smyrna, and from there, principally to England, the vessels taking it at a very low price as it serves for ballast.

The various mines belong to the Turkish and to the Greek government. The Greek government now sells its emery in lots of several tons. The Turkish government sells the entire monopoly of its mines, and consequently its operations are controlled by a single interest; but in all probability, this monopoly will be done away with, in virtue of a commercial treaty existing between Turkey and the other powers. If this takes place the price of emery will be still farther diminished.

Of the different varieties of emery employed in the arts that of *Naxos* is still preferred, and with reason, as it is more uniform in its quality than that coming from *Kulah* and *Gumuch*; nevertheless, if the best qualities of that from the island of *Nicaria* are found in abundance and that only sent into market, it will prove at least equal if not superior to that of Naxos.

Art. XXXVI.—*On American Spodumene;* by Geo. J. Brush, of the Yale Analytical Laboratory.

Read before the American Association for the Advancement of Science at New Haven, August, 1850.

Owing to the want of a complete analysis of an American Spodumene, I was induced at the suggestion of Prof. Silliman, Jr., to undertake this research.

The Spodumene from Utö has often been the subject of chemical investigation and has been analyzed by Arfvedson,* Stromeyer,† Regnault,‡ and Hagen.§ That from the Killiney locality has been analyzed by Thomson.‖

These are all the complete analyses recorded of this species. Partial analyses, however, exist of specimens from the Tyrol mountains, and from Sterling, Mass., the former by Hagen and the latter by both Hagen and Bowen.¶

The constitution of this mineral was not correctly understood prior to Hagen's analysis, until which time it had been considered as essentially a silicate of alumina and lithia. Hagen however found a portion of the so-called lithia to be soda, which discovery being confirmed renders the formulas derived from former analyses incorrect, owing to the great difference in the atomic weights of lithia and soda. Hagen's analysis of a specimen from the Utö locality gave,

			Oxygen.		Ratio.	
Silica,	66·136	=	34·36	34·36	12·26	12
Alumina,	27·024		12·63	12·72	4·55	4½
Peroxyd of iron,	·321		·09			
Lithia,	3·836		2·11	2·79	1	1
Soda,	2·683		·68			
	100·000					

from which he deduced the formula, $\dot{\mathrm{Na}}\,\dddot{\mathrm{Si}}+8\dot{\mathrm{Li}}\,\dddot{\mathrm{Si}}+6\dddot{\overline{\mathrm{Al}}}\,\dddot{\mathrm{Si}}^{2}$.

My analyses agree with Hagen's in the soda, but lead to a different formula. The specimens selected for analysis were from the Norwich and Sterling (Mass.) localities. A qualitative examination of each, showed the presence of silica, alumina, peroxyd of iron (trace), lime, lithia, and soda.

In the quantitative examination the alkalies were obtained by decomposition by hydrofluoric acid and determined as sulphates; the other constituents were obtained by fusion with carbonate of soda. That from Norwich in two analyses yielded,

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[*] Schweigger's Jour., xxii, 107.

[†] Untersuchungen, i, 426.

[‡] Ann. des Mines, (III series) 1839, 580.

[§] Pogg. Ann., xlviii, 371.

[‖] Thom. Min., i, 302.

[¶] Sill. Am. Jour., viii, 121.

	I.	II.	Mean.	Oxygen.		Ratio.
Silica,	63·06	62·72	62·39	32·67	32·67	8·04
Alumina,	28·00	28·85	28·42	13·28	13·28	3·27
Lime,	·95	1·13	1·04	·29		
Lithia,	5·67	5·67	5·67	3·12	4·06	1
Soda,	2·51	2·51	2·51	·65		
	100·19	100·88				

And that from the Sterling locality of which also two analyses were made, gave,

	I.	II.	Mean.	Oxygen.		Ratio.
Silica,	62·86	62·67	62·76	32·61	32·61	7·80
Alumina,	28·83	29·83	29·33	13·75	13·75	3·28
Lime,	·56	·71	·63	·18		
Lithia,	6·48	6·48	6·48	3·56	4·19	1
Soda,	1·76	1·76	1·76	·45		
	100·49	101·45				

The mean of the ratios calculated from the four analyses is 1 : 3·27 : 7·92 or quite nearly 1 : 3 : 8, which gives the general formula

$$\dot{R}^3\,\dddot{Si}^2+3\,\dddot{\bar{A}l}\,\dddot{Si}^2$$

and the special formula

$$(\cdot0570\,\dot{C}a+\cdot1388\,\dot{N}a+\cdot8097\,\dot{L}i)^3\,\dddot{Si}^2+3\,\dddot{\bar{A}l}\,\dddot{Si}^2$$

which requires,

8	atoms of	silica,	4618·48	= pr. ct.	64·14
3	"	alumina,	1925·40		26·76
2·4291	"	lithia,	441·27		6·12
·3999	"	soda,	154·84		2·15
·171	"	lime,	60·10		·83
			7200·09		100·00

This formula corresponds quite well with the analyses, especially in the protoxyd bases, the mean of which is almost precisely that required by the formula.

With the specific gravity 3·18 we obtain from the above the atomic volume 2264. The B atomic volume (see Mr. Dana's memoir, in this Journal, ix, 220) will be 161·7, and the C atomic volume 42·7. The isomorphism of this species with pyroxene is pointed out by Mr. Dana on page 120 of this volume.*

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* The analysis by Mr. Brush corresponds in the proportion of silica with the results of Stromeyer's investigation, who found 63·288 of silica and 28·776 of alumina. In the ratio above deduced, as well that of von Kobell's formula ($\dot{R}^3\,\dddot{Si}^2+4\,\dddot{\bar{A}l}\,\dddot{Si}^2$), the oxygen of the bases is to that of the silica as 1 : 2, the same ratio as in pyroxene.—J. D. D.

ART. XXXVII.—*Optical Examination of several American Micas;* by B. SILLIMAN, Jr., A.M., M.D., &c.

Read before the American Association for the Advancement of Science, at New Haven, August, 1850.

PRIOR to the publication of the second edition of Dana's Mineralogy, little had been done in distinguishing the several species among American micas, and in allotting them to the various localities. In connection with Professor Dana, the writer, during the passage of the Mineralogy through the press, made a number of observations respecting the optical properties of such micas as were at that time accessible. A summary of these observations will be found in that volume.* Since that work was published, the writer has continued and multiplied his observations as far as opportunity has been found for prosecuting the investigation, while former examinations have been revised. The results of the whole research as far as they are complete are exhibited in the following tables.

Much yet remains to be done, not only in confirming and extending the present measurements and adding new ones from unexamined localities, but still more in reference to the chemical character of the several compounds, which from their great resemblance in leading physical properties have hitherto been generally confounded under a common designation. This branch of the enquiry is far the most laborious, requiring a large number of rigorous chemical analyses. A beginning in it however, has been made by Mr. Craw of the Yale Laboratory, who has completed three analyses of Phlogopites from New York. The results of his research, which are particularly interesting, will be found on a following page.

The physical questions connected with the micas embrace also the translucency of the several varieties in different directions, the effects of heat and magnetism in varying the angle of the optic axes, and the value of the latter under monochromatic light in all parts of the spectrum;—and investigations on these points would well reward the observer.† I had proposed the subject last-mentioned, to my friend, Mr. W. P. Blake, before my own observations were made, and he has recently planned and constructed for himself an instrument for observations and measurements of this sort. This instrument appears to me particularly well adapted for this purpose, and with its aid we may hope for important advances in our knowledge of the physical relations of the micas.*

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* Dana's Mineralogy, p. 690.

† A few experiments were made by the author, aided by Mr. W. P. Blake, with Melloni's apparatus, to determine whether any relation in the transmission of heat existed between various micas corresponding at all to the different values of the optic axes. In these trials the mica plates were as nearly as possible of the same thickness, and they were placed so that the normal was parallel to the bundle of rays of

The instrument which I have used for the measurements given in this paper is a modification of the goniometer of Charles and Malus. It has a horizontal circle of about eight inches diameter reading to minutes, with a tangent screw and double readings. To the centre of the instrument has been adapted a simple contrivance for holding two tourmalines, and at the same time for securing the mica plate in the proper position. The tourmalines have both a horizontal and rotary movement, and are so arranged that the mica plate can be conveniently held between them in an unvarying position while the arm of the goniometer makes its revolution. The instrument is adjusted for use by bringing the specimen into such a position that the line connecting the optic axes shall be horizontal; and by turning the arm of the instrument through the requisite number of degrees, the two series of colored rings of a common binaxial mica will come successively into view. A vertical cord placed in an open window is required to complete the arrangement; the instrument is so adjusted, that the cord accurately intersects the black dots of the inner colored circle about one axis; a revolution is then made, till the cord intersects

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heat. The instrument was so adjusted that the Locatelli lamp deflected the needle in 10″ of time 30° of the scale. Thus arranged, the following results were obtained:

Mica examined.	Optic angle.	Color.	Needle deflected.	Per cent. of rays transmitted.
Muscovite of Grafton, . . .	69° 30′	light brown, ...	19°–20°	57–60
Phlogopite, Pope's Mills, .	7° 30′	white glassy, ...	12°-11°30′	36–34·5
" " "	15°	brownish yellow, ...	15°	45
" Edwards, . . .	13° 30′	yellow brown, ...	15°	45
Biotite (?) Topsham, Mc., (*probably Phlogopite.*)	. . . .	deep reddish brown, . .	13°–12°	39–36
Biotite, Monroe, N. Y., . .	. . . .	dark green, almost black,	11°	33
Muscovite, Royalston, Ms.,	57° 30′	dark brown, ...	21°	63
" Paris, Me., . . .	72° 30′	nearly colorless clear, . .	21°-21°30′	63–64·5
" Brunswick, Me.,	72° 30′	light brown, ...	21°-21°30′	68–64·5
" Jones Falls, Md.,	67°	dark green, ...	18°–19°	54–57
" Philadelphia, . .	60° 30′–61°	banded in hexag'l figures,	21°36′-22°	64·5–66

When the crystal was placed so that the rays of heat passed parallel to the optic axis, (thus the Grafton mica was placed at an angle of 34° 30′, the arrangement remaining otherwise as before) the needle was on repeated trials, deflected 24°, equal to 72 per cent. of all the rays passing while in the other position, (or with the normal parallel to the rays) only 60° passed.

From these few trials (which are regarded as only preliminary and approximative,) it will be seen that an interesting relation apparently subsists of the sort looked for, and this last experiment is particularly worthy of confirmation by extending it to numerous varieties.

* Mr. Blake presented his instrument and a series of measurements made with it to the Physical Section of the Am. Assoc., at the New Haven meeting.

in the same manner the other axis; the amount or angle of this revolution is the angle between the axes. With this arrangement there is no difficulty after a little practice in obtaining a series of measurements on the same specimen, varying from each other but a few minutes at most, without having recourse to lenses or other means of more accurately defining the field of observation or reducing the area of the colored circles. Such modes of greater accuracy are important for the more delicate physical questions previously suggested; but for the purpose of mineralogical determination, the means just described are quite sufficient, since it is shown that in a series of specimens from the same locality there is generally a difference of angle greater than any error of observation arising from the imperfection of the instrument employed.

Additional interest is given to this enquiry from a comparison of the chemical relations of the various species of mica and their corresponding differences in optical characters. For this reason we briefly recapitulate the divisions which are adopted by Prof. Dana in the late edition of his system, and which are also given with a recapitulation of the chemical formulas on p. 118 of this volume. The species of mica now recognized are muscovite, margarodite, emerylite, euphyllite, margarite, lepidolite, phlogopite and biotite. Of these, all but the last are binaxial. Our observations will be confined mainly to muscovite, lepidolite, phlogopite, and biotite.

1. *Muscovite.*—This name has been proposed by Dana to embrace those binaxial micas whose angle of polarization is between 55° and 75°, excepting however the lithia micas which, having a peculiar composition and a very high angle, are included under the species lepidolite. The terms "oblique mica" "common mica" and "binaxial mica" formerly applied to this species now fail to be distinctive, since we have other oblique and binaxial micas which belong to different species. The optic axes in this species lay in the direction of the longer diagonal of the prism. It is much the most abundant variety and is commonly found in granitic rocks.

2. *Lepidolite.*—This species embraces all the lithia micas, a group presenting however varied chemical characters which will probably be subdivided by future research. They are all binaxial and as far as observed they yield a higher angle than any other of the species of this family, being 75°–76°. The blowpipe reaction for lithia as well as its high polarization angle, enable this species to be very readily distinguished. Many of the varieties are easily recognized by their rosy or peach-blossom color.

3. *Phlogopite.*—This name was first proposed by Breithaupt for the yellowish brown mica associated with serpentine which

is found at Natural Bridge, near Diana in Jefferson county, New York. This species is distinguished by a polarization angle between 7° and 18°, the angle most commonly observed, being 13°–16°; it rarely falls below 10°; in all cases the two axes are so near that both can be distinctly seen in the field at one view, and if examined in thin plates and by a casual observer, it would be esteemed a uniaxial mica. The crystalline form is trimetric, and it occurs often in elongated and tapering hexagonal prisms, sometimes of enormous size as in the well known individuals from Pope's Mills—specimens of which in the writer's possession are 5 by 8 inches in thickness and perfect in form. The color is usually yellowish brown, bronzy yellow, and deep copper red, sometimes greenish yellow and rarely white. Its cleavage resembles that of muscovite, but the laminæ are not generally so elastic. In chemical constitution it is a distinct compound although but few analyses have yet been made of this species. Like the biotite it is remarkable for the amount of protoxyd bases which it contains and the small quantity of alumina—giving for the ratio of the oxygen of its protoxyds, alumina and silica, as deduced by Rose, $18 : 12 : 30 = 1 : \frac{2}{3} : 1\frac{2}{3}$, (more exactly $7 : 4 : 11$, according to Craw,) while in the muscovites it is generally $1 : 12 : 16$. Its localities are much more numerous than was at first supposed; they abound particularly in northern New York, in Canada, and in Morris and Sussex counties in New Jersey. One of the most noted localities of this species is Edwards in St. Lawrence county, N. Y., where it is found both colorless, of an eminently silvery luster, and also of a rich brownish yellow color.

4. *Biotite.*—This species includes the uniaxial or hexagonal micas. Most of the varieties of this species are of a dark color—often black or greenish black and transparent only in very thin laminæ. Owing to this prevalent dark color it is often difficult or quite impossible to obtain satisfactory evidence of the optical character, and there is little doubt that some localities quoted in this article as furnishing uniaxial micas, should be in fact classed among the phlogopites. Only one American variety of this species has yet been analyzed—viz., that from Monroe, N. Y., by von Kobell. They are generally magnesian micas and have for the oxygen ratio of their protoxyds, alumina, and silica, the ratio $1 : 1 : 2 = \dot{R}^3\ddot{Si} + \bar{R}\ddot{Si}$. This species and those anomalous specimens which are classed under it in the present article, but which probably belong elsewhere, offer interesting subjects for chemical examination.

Beside the *phlogopites* and *biotites*, properly so called, there are several micas which have fallen under my observation in this research which are anomalous in character. These present under the influence of polarized light an elliptical colored image, in which however it is not possible to bring out clearly the two poles of a binaxial mica, nor, on the other hand, the symmetrical cross of a uniaxial crystal. The divergence is too constant and too regular to allow the supposition that the ellipticity is due to a mal-position of the laminæ or to a separation between the thin plates (remarked on as a cause of irregularity in certain crystals by Biot). The divergence of the axes in these exceptional cases is too decided not to attract the attention of the experienced observer, and still these specimens would probably, by most persons, be set down as uniaxial, especially in thin plates. Indeed many phlogopites when viewed in thin plates appear so nearly uniaxial as scarcely to excite attention to their binaxial character, while in plates of suitable thickness they are easily measured. Those doubtful cases now under consideration are probably referable to an oblique crystalline form, but even here the study of a large number of specimens from the same locality is required before satisfactory inferences may be drawn. To this head I refer the deep reddish copper-colored mica from Franklin Furnace, Sussex Co., New Jersey, which is found in white dolomite; also a mica of similar character from St. Jerome, Canada; and that, well known to collectors, from Moriah in Essex Co., N. Y., which is more remarkable than any I have seen for its deep smoky red color as seen by transmitted light. But the most interesting specimens of this sort observed by me, are certain large crystals of a deep olive green color from the Yale College Cabinet, and which in our investigations have been referred to Monmouth, N. J., although their true locality is still doubtful. This mica is in very large rhombic crystals oblique from an *obtuse* edge. P : M = 112° - 115½°, M : M = 122° - 125°, the angle of the basal edges is 119° 30′. Plane angle of P 119°. It has a cleavage parallel to the longer axis. The obliquity of the optic axes appears to be nearly as great as that seen in some phlogopites of equal thickness, but the dark color of the mineral prevents a satisfactory examination. Should the character of this mica be confirmed by a set of good analyses, it must in all probability form a distinct species as suggested by Dana.* This variety is not to be confounded with the well crystallized mica of Greenwood furnace which, as seen in ordinary specimens, is oblique from the acute edge (sections of distorted acute rhombohedrons) and which is regarded as a uniaxial mica.

Euphyllite, margarodite and emerylite have hitherto been found in quantities too inconsiderable and in specimens generally too poorly crystallized to furnish many measurements.†

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* Mineralogy, p. 690.

† For the composition of these species, see Dana's Mineralogy, and also this volume, pages 114–118.

TABLE I.—*American Muscovite and Lepidolite Micas. Polarization angle from 55° to 76°.*

Locality of Mica.	From whom received.	Color, Form and Remarks.	Angles of axes.
New York Island, 4 m. from City N. Y.	New York Lyc. Nat. Hist., …	violet gray, with black grains disseminated in it, ……	56° 20′–56° 40′
Royalston, Mass., ……	E. Hitchcock, Jr., ……	dark brown, fine crystal; locality of the Beryls, ……	57° 30′
ib. ib. ……	ib. ib., ……	ib. ib. another specimen, ……	58°–59°
Pennsbury, Penn., ……	T. Seale, ……	smoky brown, striated; color in blotches, ……	59°
Philadelphia, Penn., ……	Lederer Cabinet, T. Conrad, ..	greenish gray, banded; alternate bars of color, ……	60° 30′–61°
ib. ib. near Fairmount, …	T. Seale, ……	smoky brown; resembles Pennsbury mica, ……	62°–62 30′
Oxford, Maine, ……	Dr. True, ……	light brown; perfect crystals transparent in transverse direction, ……	62° 42′–63°
Monroe, Conn., ……	Lederer Cabinet, ……	brown with patches, of dark brown mottled, ……	64° 30′–65° 30′
Royalston, Mass., ……	Cambridge Cabinet, by Prof. Lovering,	violet brown; in thick plates, ……	65°
Local. ? ……	C. M. Wheatley's Cabinet, ……	greenish gray; in perfect crystals, ……	65° 30′–66°
Falls road, 2¼ m. from Baltimore, …	T. Seale, ……	transparent brown, with scales of green, ……	65° 30′–65° 40′
Near Ellicott's Mills, Md., ……	ib. ib., ……	ib. ib. Baltimore and Ohio Railroad, ……	66° 30′
"Jones' Falls," near Baltimore, ……	G. Gibbes and W. S. Vaux, ..	blackish green; symmetrically banded, with dark grains of chrom. iron ? ……	66° 15′–66° 30′
Greenfield, Conn., ……	Yale College Cabinet, ……	greenish yellow, in granite boulder, ……	66° 30′–67°
Haddam, Conn., (Quarry Hill,) ……	Mr. Burr, ……	clear brownish green, in granite, ……	67°
Grafton, New Hampshire, ……	Bowers, ……	light brown, transparent, ……	67° 30′
Unionville, Penn., ……	T. Seale, ……	white; corundum locality, ……	67°–67° 28′
Ackworth, N. H., ……	Yale College Cabinet, ……	greenish gray, in granite, ……	67° 15′–67° 30′
Grafton, N. H., another specimen, …	Bowers, ……	light brown, with flattened quartz and tourmaline, ……	68° 5′–68° 20′
Templeton, Mass., ……	E. Hitchcock, Jr., ……	transparent brown, ……	69° 30′–69° 40′
Orange, Mass. ……	ib. ib., ……	ib. ib. beautiful crystals, ……	69° 30′–69° 40′
Willimantic falls, Conn., ……	……	brownish green, transparent, in granite, ……	69° 30′–69° 50′
Pennsbury, Penn., ……	T. Seale, ……	brown crystals; another locality, ……	69° 27′–70°
Royalston, Mass., ……	E. Hitchcock, Jr., ……	dark brown; 2d locality, ……	69° 40′–70°

Table continued.

Locality of Mica.	From whom received.	Color, Form and Remarks.	Angles of axes.
Grafton, N. H.,	Bowers,	light brown; 3d specimen,	69°–69° 30′
Middletown, Conn.,	J. D. Dana,	brownish; feldspar quarry,	70°–70° 30′
Chester, Hampden Co., Mass.,	Yale College Cabinet,	greenish white, in granite boulder,	70°–70° 30′
Norwich, Mass.,	E. Hitchcock, Jr.,	greenish yellow; spodumene locality,	70° 30′
Pennsbury, Penn., (3d Local.)	T. Seale,	brownish green; in coarse granite,	70°–70° 30′
Goshen, Mass.,	Yale College Cabinet,	greenish yellow; with spodumene,	70°–70° 30′
Greenfield, N. Y.,	Mr. Powers,	brownish; chrysoberyl locality,	70° 45′–71°
Haddam, Conn.,	Mr. Burr,	brownish; in large plates,	70°
Gouverneur, N. Y.,	Dr. B. F. Hough,	brownish-white, in boulder,	70°
Templeton, Mass., (2d spec.)	E. Hitchcock, Jr.,	transparent brown,	70° 15′
Leiperville, Del. Co., Pa.,	T. Seale,	faint greenish; plicated plates,	70° 30′–71°
Jefferson Co., N. Y.,	Dr. B. F. Hough,	greenish; in a boulder,	71°–71° 30′
Hebron, Maine,	Dr. True,	light brown transparent, in thick masses,	71° 40′–71° 50′
Norwich, Mass.,	E. Hitchcock, Jr.,	yellowish green transparent; 2d specimen,	71° 45′
Haddam, Conn.,	Myself,	ib. ib.; columbite locality,	71° 30′–71° 45′
E. Chester, Westchester Co., N. Y.,	Yale College Cabinet,	ib. ib.; boulder,	71° 30′–72°
Paris, Maine,	Dr. True,	ib. ib.	72° 15′–72° 30′
ib. ib.,	Prof. O. P. Hubbard,	ib. ib.; another specimen,	72° 30′
Brunswick, Maine,	Prof. Lovering,	whitish brown; silvery mica,	72° 37′–72° 50′
Gouverneur, N. Y.?	Cambridge Cabinet,	fair rosy color; no lithia reaction,	73°–73° 5′
Paris, Maine,	Yale College Cabinet,	whitish green; with green tourmaline,	74°–74° 30′
ib. ib.,	ib. ib.	ib. another specimen,	73°
Orange, N. H.,	W. P. Blake,	gray, with flattened tourmaline, quartz and feldspar,	73°–74°
Pounal, Maine,	Dr. True,	nearly colorless; lithia? mica,	74° 50′–75°
Goshen, Mass.,	Yale College Cabinet,	yellowish green; with indicolite,	75°
ib. ib.,		another specimen,	75° 30′–76°
Lenox, Mass.,	Lederer Cabinet,	rose colored lithia mica; with albite,	75°–75° 30′

TABLE II.—*American Phlogopite Micas.*

Locality of Specimen.	Whence obtained.	Color, Form and Remarks.	Angle.
Pope's Mills, St. Lawrence Co., N. Y.,	Lederer Cabinet,	a glassy transparent crystal, about $\frac{1}{4}$ inch thick,	7°–7° 30′
Edwards, N. Y.,	C. M. Wheatley's Cabinet,	rich reddish brown in large clear plates and very unlike either of the other varieties from Edwards; resembles the Franklin, N. J., specimens,	10° ?
St. Lawrence Co.? N. Y.,	Lyc. Nat. Hist., N. Y.,	yellowish,	10° ?
Vrooman's Lake, N. Y.,	Dr. B. F. Hough,	in long crystals of a yellow color; resembles the mica of Natural Bridge,	10° 30′–10° 50′
Edwards, N. Y.,	ib. ib.,	rich yellowish brown color,	11°
Warwick, Orange Co., N. Y.,	C. M. Wheatley's Cabinet,	in limestone, yellowish, slightly transparent, uneven,	11° ?
Falls of the Grande Calumette, Canada,	T. S. Hunt,	yellowish green, in limestone with pyroxene and idocrase; crystals sometimes many inches long; eminently beautiful mica,	13°–13° 12′
Pope's Mills, St. Lawrence Co., N. Y.,	Dr. Crawe,	large crystals of a fine yellowish brown; specimen measured 9 by 5 inches,	13° 30′
Edwards, N. Y.; 2d specimen,	ib. ib.,	yellowish brown,	13° 30′
Churches Mills, Rossie, N. Y.,	Dr. Hough,	resembles the Pope's Mills; yellowish brown,	13° 30′–14°
Near Skinner's Bridge, Rossie, N. Y.,	ib. ib.,	silvery yellow mica,	14°
Carlisle, Mass.,	Lyc. Nat. Hist., N. Y., from Dr. Torrey,	in limestone vein with fibrolite, &c.; rich yellowish brown, like Natural Bridge,	14°
Rossie, N. Y., near Mrs. Story's,	Dr. Hough,	light yellowish, with crystals of magnetic iron?	15°
Pope's Mills, St. Lawrence Co.,	Dr. Crawe,	brownish yellow hexagonal crystal 3 inch. diameter; plate examined $\frac{1}{8}$ inch thick; axis in the line of the shorter diagonal,	15°
Natural Bridge, Jefferson Co., N. Y.,	Lederer Cabinet and Dr. Hough,	rich yellow; associated with serpentine; same as analyzed by Meitzendorff,	15°
ib. ib.,	Dr. Hough,	another specimen,	16°
Edwards, N. Y.,	Dr. Crawe,	white silvery, curved crystals, often opake,	15° 30′–16° 30′
Vicinity of Rossie, N. Y.,	Mr. Powers,	rich yellow brown; probably the same as Gouverneur,	16° 7′–16° 15′
Essex, N. Y.,	Lyc. Nat. Hist., N. Y.,	in limestone in beautiful crystals not over $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter; hexagonal; deep rich brown color,	16° 30′
Upper Ottawa, Canada,	T. S. Hunt,	reddish yellow transparent, in granite,	17° 30′–18°

Table continued.

The following are probably of the same species but are generally too dark in color to admit the passage of light in plates of sufficient thickness to define well the two sets of ellipses. Nevertheless in several cases the angle may be approximately estimated, and in others the mica may be more properly arranged with the anomalous varieties which present equivocal evidence of a binaxial character.

Locality of specimen.	Whence obtained.	Color, Form and Remarks.	Angle.
Moriah, Essex Co., N. Y.,	Lederer Cabinet,	very dark smoky red, in thin plates by transparent light,	Estimat'd 16°–17°
Gouverneur, N. Y.,	Dr. Hough,	brownish copper red; yellowish; in hexagonal plates like Pope's Mills,	
Somerville, N. Y.,	Dr. Hough,	faint brownish, with blood red spots, which magnified are seen to be garnet,	Estimated 5°–7°
Burgess, Canada West,	T. S. Hunt,	bronzy, almost metallic luster; a very brownish yellow, semi-transparent if thin; opake in plates a line thick; slightly elastic only; found with apatite in sandstone,	Angle very low.
Franklin, N. J.,	Lederer Cabinet,	bronzy yellow, distinct from the red mica of same place,	About 14°
Burgess, Canada West,	T. S. Hunt,	whitish yellow; imperfect specimen, with particles of foreign matter, resembling specimen from Natural Bridge,	About 10°
Fine, St. Lawrence Co., N. Y.,	Dr. Hough,	very dark olive brown; opake in plates over a line thick; clearly binaxial,	Estimat'd 10°–12°
Amity, N. Y.,	ib. ib.,	opake silvery white; resembles in general character a muscovite,	10°–12°
Sterling Mine, Morris Co., N. J.,	F. Canfield,	rich yellowish brown, inclining to red; in limestone.	
Suckasunny Mine, N. J.,	ib.	deep olive brown, inclining to yellow; in limestone.	
Newton, N. J.,	ib.	yellow; imperfect and very small; in limestone.	
Lockwood, Sussex Co., N. J.,	ib.	deep olive brown, like the mica of Fine, N. Y.; in limestone.	

To the foregoing may be added the anomalous micas before described from Monmouth (?) N. J., (Maine?), from Franklin furnace, N. J., and several specimens which the author has found in various cabinets, but which being without labels he has been unable as yet to refer to the proper localities. Another phlogopite from Oxbow, N. Y., has been received while these pages are in the press.

In the accompanying tables we have given for each specimen measured, its locality, color, the source whence received, the angle between the optic axes, and other observations bearing on their history. It may afford a more correct impression of the present state of this investigation to remark that specimens from over *one hundred* American localities of mica have been examined besides a considerable number of uncertain locality; and from many of these localities very numerous specimens have been measured. Thus there have been measured of *muscovite* specimens from about 50 localities; of phlogopite over 30; of euphyllite 2; of margarodite 1; of biotite about 12, and of doubtful species 3 or 4.

Biotite.—The number of localities in the United States furnishing uniaxial mica (biotite) has been constantly diminishing since the commencement of these investigations, as increased skill in observation and improved means of examination have shown one after another of the reddish and yellow or brown colored micas to have more or less decidedly the characters of phlogopite.

Thus the dark brown mica of Fine, the red micas of Moriah, of Sterling, of Franklin, and of Gouverneur, have successively been thrown out of the list of biotites into the binaxial species. Others remain in doubt as those of Topsham, Me., and Easton, Pa.

Greenwood Furnace, Monroe, Orange County, N. Y., is the locality of a very remarkable and perfectly crystallized biotite. It is figured by Beck,* and fully described also by Dana,† and it appears to have been analyzed by von Kobell,‡ as quoted by both the authors just cited. The remarks made on a previous page respecting the equivocal optical character of some of the micas apply to this variety also. It is opake in plates over one-twelfth of an inch thick, but of rich olive green in thin plates.

The figure of its rings under polarized light is decidedly elliptical, but not so much so perhaps as to require any other explanation than the remark of Biot, before quoted, respecting the power of thin plates to disturb the ray and produce the effect of binaxial structure in a uniaxial crystal. The author has a new analysis of this variety in progress the results of which he will present on a future occasion. The chemical constitution of very few American biotites has been examined: indeed the locality just referred to is the only one cited. Von Kobell's result corresponds with the formula given on page 375.

Mica of Monroe, N. Y.—This mica from the same town as the last is also uniaxial and gives a figure almost entirely circular. It is distinguished by its bronzy lustre and dark greenish olive color inclining to gray or black. It is imperfectly transparent, having by transmitted light a dusky or hazy appearance. It occurs in plates of immense size, which are marked on the cleavage surfaces with rhombic and triangular figures, (no distinct lateral planes have however been found,) as well as with transverse cleavage lines. It is slightly elastic but very tough. One specimen which the author has seen in the cabinet of Mr. C. M. Wheatley in New York is nearly two feet in diameter. Mr. Horton of Monroe has also furnished the writer with numerous very large specimens. No analysis of it has been published, but the author hopes to present one at a future time.

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* Min., N. Y., p. 37.

† Min. (1850), 360.

‡ Kastn. Archv., xii, 29.

The white mica of Easton, Pa., which is very silvery and slightly elastic and opake in thick plates, is probably a biotite, and, excepting the very similar white mica of Amity, N. Y., is the only white uniaxial variety yet noticed in this country.

The Black micas are almost universally referable to the species biotite, although many micas usually called black in collections are in reality dark brown and olive green and are frequently referable to phlogopite. Unfortunately very few of the localities of this variety of color found in cabinets are labelled. I have one from Moors Slide on the Ottawa in Canada, furnished me by Mr. Hunt of the Canada Geological Commission. Another black mica is found in St. Lawrence Co., N. Y., of which specimens were obtained by the author from the cabinets of Mr. Wheatley and of the N. Y. Lyceum in New York. Two black micas from the Cambridge cabinet are unaxial, locality not known.

Geological relations.—It is worthy of notice that the species muscovite is found almost entirely in granitic rocks; in no instance as far as I have seen, has a specimen of this species been found in a lime rock. On the other hand, the phlogopites, with a single exception, so far as has been ascertained, are found in limestone and often in dolomitic beds. The biotite is less well determined, but, as regards the black micas, they are always, it is believed, found in granitic rocks. Thus New England is the region of muscovites, and northern New York, New Jersey and Canada, that of phlogopite. The few specimens of muscovite from St. Lawrence Co. were obtained from granite boulders. The only specimen of phlogopite yet observed in New England is from Carlisle in Mass., where also it is found in a limestone vein with chondrodite and fibrolite, an interesting confirmation of the suggestion here put forth. Can this distribution be unconnected with the chemical composition of the several compounds? The magnesian character of the phlogopites would seem to indicate the dolomitic position of the species, while the absence of this element in the muscovites is a negative fact of equal significance.

The writer cannot close this paper without tendering his thanks to numerous correspondents who have in the kindest manner responded to his persevering enquiries for specimens. It is intended that the foregoing tables should embrace in all cases the source from whence the specimens were obtained, as it is of the greatest importance that accuracy and authenticity should be obtained in this particular, for the sake of future observers. The author retains all the localities referred to in his own collection so labelled as to avoid error, and they are at all times open to the inspection of those who wish to examine them.*

ART. XXXVIII.—*Analyses of Phlogopite from St. Lawrence County, N. Y.;* by WM. J. CRAW, of the Yale Analytical Laboratory.

Read before the American Association for the Advancement of Science, at New Haven, August, 1850.

THE mica called Phlogopite has been analyzed by Meitzendorff, in Poggendorff's Annalen, volume viii, page 157. An analysis has likewise been published by Svanberg, in the Transactions of the Royal Swedish Academy for 1839, of a mica which has been supposed to be phlogopite, but as it does not agree in atomic proportions with that from New York, it very probably may not come under this species.

Meitzendorff gives the following as the composition of the specimen which he analyzed: it was from Jefferson Co., N. Y., and probably from Natural Bridge.

	$\overset{\cdots}{\bar{\text{S}}}\text{i}$	$\overset{\cdots}{\bar{\text{A}}}\text{l}$	$\overset{\cdots}{\bar{\text{F}}}\text{e}$	$\dot{\text{M}}\text{g}$	$\dot{\text{K}}$	$\dot{\text{N}}\text{a}$ & some $\dot{\text{L}}\text{i}$	Fl	ign.
	41·30	15·35	1·77	28·79	9·70	0·65	3·30	0·28=101·14
Oxygen,	21·46	7·17	0·53	11·31	1·65	0·17		

The specimens analyzed by me were all from Edwards, St. Lawrence Co., N. Y. No. 1, had a deep yellowish brown color, in broad plates.

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* It is worthy of remark that the species Phlogopite has not yet been mentioned as occurring in Europe. Dufrenoy† mentions and figures micas from Clayette in France, another from the department of Finistère and others from Lake Baikal which are probably to be referred to this species, but no optical examination appears to have been made of them. Sir David Brewster quotes a mica of 14° measured by him, but does not say from whence he procured it. Indeed optical observers have seemed heretofore to attach no importance to the localities of the specimens measured by them, and hence their observations are rendered nearly useless to the mineralogist. It cannot be doubted that the limestone rocks of Europe will supply many examples of phlogopite. The author would take this opportunity to suggest that the *light and dark greenish micas of Vesuvius* are referable to *phlogopite* as he has satisfied himself from the examination of authentic specimens in the collection of Yale College. The black Vesuvian micas are undoubtedly uniaxial.

† Traité de Minéralogie, iii, p. 647, 1847, also Dana, p. 359.

No. 2, was a transparent and colorless crystal of a silvery lustre; and

No. 3, was a part of the same crystal rendered quite opaque and silvery by the absorption of water. The crystal which furnished Nos. 2 and 3 was originally 6 by 8 inches in surface dimensions.

No. 1, gave reactions for silica, alumina, magnesia, potash and fluorine, with small quantities of peroxyd of iron and soda, and a doubtful trace of lithia.

Nos. 2 and 3 gave silica, alumina, magnesia, potash and soda, with traces of water and fluorine.

The following are the results of analysis:

	No. 1.		No. 2.	No. 3.
$\dddot{\mathrm{Si}}$	40·145		40·358	40·36
$\bar{\dddot{\mathrm{Al}}}$ with a little $\bar{\dddot{\mathrm{Fe}}}$	17·356		16·450	16·084
$\dot{\mathrm{Mg}}$	28·099		29·554	30·247
$\dot{\mathrm{K}}$	10·564		7·226	6·066
$\dot{\mathrm{Na}}$	0·63		4·938	4·39
Fl	4·202	loss by ign.	0·952	2·65
	100·996		99·478	99·797

Oxygen Ratios.

	No. 1.		No. 2.		No. 3.	
$\dddot{\mathrm{Si}}$	20·86		20·97		20·97	
$\bar{\dddot{\mathrm{Al}}}$	8·11		7·69		7·52	
$\dot{\mathrm{Mg}}$	11·04	12·99	11·61	14·11	11·89	14·05
$\dot{\mathrm{K}}$	1·79		1·23		1·03	
$\dot{\mathrm{Na}}$	0·16		1·27		1·13	

The ratios are respectively 1·6 : 1 : 2·56; 1·83 : 1 : 2·73; 1·87 : 1 : 2·78; the mean of these is 1·77 : 1 : 2·69, which equals very nearly 7 : 4 : 11, and corresponds with the formula $7\dot{\mathrm{R}}^3\dddot{\mathrm{Si}}+4\bar{\dddot{\mathrm{Al}}}\dddot{\mathrm{Si}}$. The equality between the oxygen of the silica and that of the bases will be observed; and if $\dot{\mathrm{R}}^3$ and $\bar{\dddot{\mathrm{Al}}}$ may replace one another, the formula becomes $(\dot{\mathrm{R}}^3, \bar{\dddot{\mathrm{Al}}})\dddot{\mathrm{Si}}$, a common type among the silicates.

The per-centage corresponding to this formula is as follows, excluding the fluorine, which is not found in analyses 2 and 3.

$\dddot{\mathrm{Si}}$	$\bar{\dddot{\mathrm{Al}}}$	$\dot{\mathrm{Mg}}$	$\dot{\mathrm{K}}$
41·60	16·82	30·01	11·57=100·00

In No. 1, the $\bar{\dddot{\mathrm{Al}}}$ contains a small proportion of $\bar{\dddot{\mathrm{Fe}}}$, which increases the amount of oxygen from the peroxyds so as to make the protoxyds and silica appear smaller in proportion than they really are, and the determination of the silica is also, probably, somewhat too low.

Meitzendorff's analysis affords the ratio 13·13 : 7·70 : 21·46; which equals 1·7 : 1 : 2·78, and corresponds quite closely with the ratio 7 : 4 : 11, the same which is afforded by the analyses above.

The fluorine, however, comes in as an important element, and one which it is somewhat difficult to dispose of, in a perfectly satisfactory manner.

H. Rose considers the fluorine to exist as fluorid of potassium, and gives the formula $\mathrm{K\,Fl}+(3\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}+2\bar{\dddot{\mathrm{R}}}\,\dddot{\mathrm{Si}}.)$ This corresponds to the ratio 3 : 2 : 5—the potash being removed from the other protoxyds, as a fluorid.

Rammelsberg remarks that the fluorine may be considered as silicofluorid of potassium; but Rose is opposed to this view, on the ground that it would change the ratio of the oxygen in the several oxyds. This it would do, if it were considered simply as silicofluorid of potassium, but if, in accordance with the recent views of Rammelsberg published in his last supplement, it is taken as replacing oxygen in the several compounds, the ratio will remain unaltered. In this view, the formula $7\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}+4\bar{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}$, represents correctly the constitution of the mineral, if we suppose the oxygen partly replaced by fluorine.

The apportionment of the fluorine and oxygen to the several compounds is as follows:—

1. *Meitzendorff's Mica.*

		Fluorine.	Oxygen in residues.			Sum.
Combined with	Si	1·65	$\dddot{\mathrm{Si}}$		20·68	22·33
	Al	0·60	$\bar{\dddot{\mathrm{Al}}}$	6·92	7·45	8·05
	—	—	$\bar{\dddot{\mathrm{Fe}}}$	0·53		
	Mg	0·90	$\dot{\mathrm{Mg}}$	10·94	12·68	13·73
	K	0·15	$\dot{\mathrm{K}}$	1·58		
			$\dot{\mathrm{Na}}$	0·16		

Ratio 1·7 : 1 : 2·78.

2. *Mica from Edwards.* *Analysis* 1.

		Fluorine.	Oxygen in residues.			Sum.
Combined with	Si	2·101	$\dddot{\mathrm{Si}}$	19·97		22·071
	Al	0·764	$\bar{\dddot{\mathrm{Al}}}$	7·79		8·554
	Mg	1·146	$\dot{\mathrm{Mg}}$	10·56	12·43	13·767
	K	0·191	$\dot{\mathrm{K}}$	1·71		
			$\dot{\mathrm{Na}}$	0·16		

Ratio = 1·6 : 1 : 2·58.

The ratio of the silico-fluorids to the silicates is 1 : 30 in Meitzendorff's analysis, and about 1 : 24 in the mica of Edwards; according to the first, the detailed formula is—

$$30[7\mathrm{R}^3\,\dddot{\mathrm{Si}}+4\bar{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}]+1[7(3\mathrm{R\,F}+\mathrm{Si\,F}^3)+4(\bar{\mathrm{Al}}\,\mathrm{F}^3+\mathrm{Si\,F}^3)]$$

and according to the second—

$$24[7\dot{\mathrm{R}}^3\,\dddot{\mathrm{Si}}+4\bar{\dddot{\mathrm{Al}}}\,\dddot{\mathrm{Si}}]+1[7(3\mathrm{R\,F}+\mathrm{Si\,F}^3)+4(\bar{\mathrm{Al}}\,\mathrm{F}^3+\mathrm{Si\,F}^3)].$$

Analyses 2 and 3 correspond closely with Meitzendorff's in the ratio, if this view of the fluorine be taken, and the varieties with fluorine and those without, which are alike in polarization, thus come under one general formula.

Extracts from the Proceedings of the Twentieth Meeting of the British Association, held at Edinburgh, July, 1850.[*]

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

On Atlantic Waves, their Magnitude, Velocity, and Phenomena; by DR. SCORESBY.

DURING *two* passages across the Atlantic in 1847–8, I had opportunities for investigating certain elements respecting deep-sea waves more favorable than had ever before occurred within my experience in navigation. These observations, it should be noted in the outset, and the results deduced from them, were entirely uninflenced by, and separate from theory. They form but a contribution to this interesting branch of natural phenomena; but I offer them the more readily from the circumstance of their entire independency and speciality. It was in our return voyage from America that the highest seas occurred, when the circumstances adapted for interesting observations were singularly favorable; for, whilst the magnitude and the peculiar construction of the upper works of the ship—the Hibernia—afforded various platforms of determinate elevation above the line of flotation for observations on the height of the waves, the direction of the ship's course, with respect to that of the waves, was generally so nearly similar as to yield the most advantageous agreement or accordance for observations on their width and velocity. These observations I shall extract, in their order, from my journal kept during the homeward passage. My first observation worth recording is under the date of March 5, 1848, when the ship was in latitude about 51°, and longitude (at noon) 38° 50′ W.—the wind then being about W.S.W., and the ship's course, true, N. 52° E. At sunset of the 4th the wind blew a *hard gale*, which, with heavy squalls, had continued during the night; so that all sail was taken in but the storm-staysail forward. The barometer stood at 29·50 at 8 P. M., but fell so rapidly as to be at 28·30 by 10 the next morning. In the afternoon of this day I stood some time on the saloon deck or cuddy roof,—a height, with the addition of that of the eye, of 23 feet 3 inches above the line of flotation of the ship,—watching the sublime spectacle presented by the turbulent waters. I am not aware that I ever saw the sea more terribly magnificent. I was anxious to ascertain the height of these mighty waves; but found almost every wave rising so much above the level of the eye, as indicated by the intercepting of the horizon of the sea in the direction in which they approached us, as to yield only the *minimum* elevation, and to show that the great majority of these rolling masses of water possessed a height of considerably *more* than twenty-four feet (including depression as well as altitude,) or, reckoning from the mean level of the sea, of *more* than twelve feet. Exposed as the situation was, I then adventured to the larboard paddle-box, which was about seven feet higher, where the level (as ascertained afterwards at Liverpool, allowance being made for the alteration in the draught of water of the ship,) was twenty-four feet nine inches above the sea.

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[*] From the Athenæum, Numbers 1189, 1190, 1191.

This position, with five feet six inches, the height of my eye, gave an elevation altogether of thirty feet three inches for the level of the view then obtained,—a level, it should be remarked, which was very satisfactorily maintained during the instants of observation, because of the whole of the ship's length being occupied within the clear "*trough* of the sea," and in an even and upright position, whilst the nearest approaching wave had its maximum altitude. Here, also, I found at least *one half* of the waves which overtook and passed the ship were far above the level of my eye. Frequently I observed long *ranges* (not acuminated peaks) extending one hundred yards, perhaps, on one or both sides of the ship,—the sea then coming nearly right aft,—which rose so high above the visible horizon, as to form an angle estimated at two to three degrees (say 2½°) when the distance of the wave summit was about one hundred yards from the observer. This would add near thirteen feet to the level of the eye. And this measure of elevation was by no means uncommon,—occurring, I should think, at least once in half a dozen waves. Sometimes peaks of crossing or crests of *breaking* seas would shoot upward at least ten or fifteen feet higher. The *average wave* was, I believe, fully equal to that of my sight on the paddle-box, or more,—that is, $\frac{30}{2} = 15$ feet, or upwards; and the *mean highest waves*, not including the broken or acuminated crests, about forty three feet above the level of the hollow occupied at the moment by the ship. Illuminated as the general expanse not unfrequently was by the transient sunbeam breaking through the heavy masses of the storm-cloud, and contrasting its silvery light with the prevalent gloom, yielding a wild and partial glare, the mighty hills of waters rolling and foaming as they pursued us, whilst the gallant and buoyant ship—a charming "sea-boat"—rose abaft as by intelligent anticipation of their attack, as she scudded along, so that their irresistible strength and fierce momentum were harmlessly spent beneath her and on her outward sides,—the storm, falling fiercely on the scanty and almost denuded spars and steam chimney raised aloft, still indicated its vast, but as to us innoxious, power, in deafening roarings,—altogether presented as grand a storm-scene as I ever witnessed, and a magnificent example of "the works of the Lord," specially exhibited to sea-going men, "and his wonders in the deep." In the afternoon of the same day the gale again increased, blowing, especially during the continuance of a much protracted hail-shower, terrifically,—roaring like thunder whilst we scudded before it, causing the ship to vibrate as by a sympathetic tremor, and the tops of rolling waves, too tardy, rapid as was their actual progress, for the speed of the assailing influence, to be carried off and borne along on the aerial wings in a perfect drift of spray! But during the period of these most vehement operations of nature, I was fortunately enabled, from familiarity with sea enterprise, to pursue my observations with entire satisfaction. The next day—March 6—added to the interest of these investigations by developing the character of the Atlantic waves under a long and fiercely-continued influence of a little varying wind. It had blown a heavy gale, violent in the showers, from the north-westward, from Saturday evening the fourth, to the evening of Sunday, from twenty-six to thirty hours; during the night, too, of Sunday it had again blown hard (abating towards the morning of Monday), and making a total continuance of the storm, in *its violence*, of about thirty-six hours.* I renewed my observations on the waves at ten A. M.—the storm having been then subdued for several hours, and the height of the waves having perceptibly subsided. Soon I observed, when standing on the saloon-deck, that ten waves, in one case, came in succession, which all rose above the apparent horizon,—consequently they must have been more than twenty-three feet, probably the *average* might be about twenty-six from ridge to hollow. At this period I also found that occasionally (that is, once in about four or five minutes,) three or four waves in succession, as seen from the paddle-box, rose *above* the visible horizon,—hence they must, like those of the preceding day, have been thirty feet waves. But one important *difference* should be noted—viz., that they were of no *great* extent on the ridge, presenting, though more than mere conical peaks, but a moderate elongation.

Another subject of consideration and investigation, on this occasion, was the period of the regular waves overtaking the ship, and the determination, proximately, of the actual width or intervals, and their velocity. 1. The ship was then going *nine* knots only, the free action of the engines being greatly interfered with by the heavy sea running, and the lines of direction of the waves and the ship's course differed about 22½ degrees, the sea being two points on the larboard quarter,—in other words, the true course of the ship was east; the direction *from* whence the sea came was W.N.W. 2. The period of regular waves in incidental series, overtaking the ship, were observed as follows:—

Waves.		Min. Sec.	Mean.
20	occupied	5 03	16″·5
10	"	2 35	15 ·5
10	"	2 50	17 ·0
10	"	2 45	16 ·5
8	"	2 16	17 ·0
General average,			16 ·5

3. The length of the ship was stated to be two hundred and twenty feet. The time taken by a regular wave to pass from stern to stem appeared, on a mean of several observations, to be about six seconds. Hence 6″ : 220 feet (the width passed over in that time) : : 16·5 feet to 605 feet (the width passed over betwixt crest and crest.) But this extent, by reason of the obliquity of the direction of the waves to the course of the ship, is found to be elongated about 45 feet, reducing the probable mean distance of the waves to five hundred and fifty-nine feet. Independently of this process, I had previously estimated the distance of the wave crests, ahead and astern when the ship was in the hollow, as I stood near the center of the ship's length on the paddle-box, at three hundred feet each way, by comparing the intervals betwixt my position and the place of the wave-crest, with the known length of the ship. This comparison frequently re-considered and repeated, subsequently yielded, in much accordance with the former, a total width, in the line

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* The barometer on Saturday, at 8 P. M., was at 29·50; at 6 A. M. of Sunday it had fallen to 28·30, being 1·2 inches in ten hours. At 6 P. M. of the latter day it had risen to 30·00 inches.

of the ship's course, of about six hundred feet. 4. But the total distance betwixt the crests of two waves, then reckoned at five hundred and fifty feet, a distance passed by the wave in 16·5 seconds of time, by no means indicates, it is obvious, the real velocity of the wave, as the ship meanwhile was advancing nearly in the same direction at the rate of nine knots, that is, nine geographical miles, or (6,075·6 feet × 9 =) 54,680·4 feet per hour, or 15·2 feet per second. During the time, therefore, of a wave passing the ship = 16·5″, the ship would have advanced on its course 15·5 × 15·2 = 250·6 feet. Reducing this for the obliquity of two points we have 231·5 feet to be added to the former measure, five hundred and fifty nine feet, which gives 790·5 feet for the actual distance traversed by the wave in 16·5 seconds of time, being at the rate of $\left(\frac{3{,}600'' \times 790{\cdot}5}{16{\cdot}5} = \right)$ 17,251·7 feet, or 32·67 English statute miles per hour. To know how far this result is but proximate, it should be considered that, of the several elements employed in the calculation, all but one might be deemed accurate. The interval of time occupied by the transit of a wave with respect to the position of the ship, the *direction* of the ship's motion with relation to that of the waves, and the speed of the ship through the water,—may all be recorded as, essentially, accurate. The element in doubt is that of the average distance from summit to summit of the waves. This distance, it has been seen, was, by a twofold process of observation or comparison accordantly assumed. The value of the judgment derived from rapid comparison of measures by an eye accustomed to such estimations is, it should be observed, far higher than might be generally considered. The practical military commander or engineer officer is able to make, by mere inspection of the ground before him, remarkably close estimates of spaces and distances. When engaged in the Arctic whale fishery, I was enabled, from habit and comparison of unmeasured spaces with known magnitudes, to estimate certain distances with all but perfect accuracy. Thus, as to a circumstance in which we were most deeply interested—the near approach of a boat to a whale—I found it quite practicable, whenever the pursuing boat approached within twice or thrice its length (except when the position was near end on) to estimate the distance to less than a yard. Now, the means of comparison by the eye as to the estimation of the breadth of the Atlantic waves, was that of the ship's length of 220 feet. When the ship was fairly in the middle of the depression betwixt two waves it was assumed, with reference to this known measure, that something obviously less, but not greatly so, than the ship's length, was the distance of each of the two waves then contemplated—giving a total width of about six hundred feet. But the comparison of the time required by a wave to pass from stem to stern, with the average time of transit of an entire wave, yielded a much better result; and, on much consideration of the subject, I am inclined to believe that the estimate is a tolerably close approximation to the truth. It should be observed, too, that as the headway of the ship, in the direction of the course of the wave—being a known quantity—it was favorable to the accuracy of the estimate. For, assuming an error in the width of the waves to have occurred, say to the amount of one-twelfth of the whole, or forty-nine feet—the effect upon the calculated velocity of the wave would have been only about a sixteenth, or 2·16 miles per hour. The form and character of these deep-sea waves became at the same time interesting subjects of observation and consideration. In respect to form, we have perpetual modifications and varieties, from the circumstance of the inequality of operation of the *power* by which the waves are formed. Were the wind perfectly uniform in direction and force, and of sufficient continuance, we might have in wide and deep seas, waves of perfectly regular formation. But no such equality in the wind ever exists. It is perpetually changing its direction within certain limits, and its force too, both in the same place and in proximate quarters. Innumerable disturbing influences are therefore in operation generating the varieties more or less observable in natural sea waves. In regard to my own observations of the actual forms of waves, nothing particularly new could be expected from an inquiry of this kind in regard to phenomena falling within the perpetual observation of sea-going persons; yet, at the risk of stating what might be deemed common, I will venture to transcribe from my notes made with the phenomena before me, the leading characteristics which engaged my attention. During the height of the gale (March 6th) the *form* of the waves was less regular than after the wind had, for some time, begun to subside. Though in many cases when the sea was highest the succession of the primary waves was perfectly distinct, it was rather difficult to trace an identical ridge for more than a quarter to a third of a mile. The grand elevation in such case sometimes extended by a straight ridge or was sometimes bent as of a crescent form, with the central mass of water higher than the rest, and, not unfrequently, with two or three semi-elliptical mounds in diminishing series, on either side of the highest peak. These principal waves, too, it should be noted, were not continuously regular, but had embodied in their general mass many minor, secondary and inferior waves. Neither did the great waves go very prevalently in long parallel series like those retarded by shallow water on approaching the shore; but every now and then changed into a bent cuneiform crest with breaking acuminating peaks. On the following morning (March 7,) after a second stormy night, wind S.S.W. (fine), we had a heavy and somewhat cross sea (from the change of wind from W.S.W. to S.S.W.). But the almost unabated magnitude of the more westerly waves indicated a continuance of the original wind at some distance astern of us. The gale had moderated at daylight, and the weather became fine; but as the sea still kept high, its undulations became more obvious and easily analyzed. At three in the afternoon, when about a third part of the greater undulations averaged about twenty-four feet from crest to hollow, in height, these higher waves could be traced right and left as they approached the ship to the extent of a quarter of a mile on an average, more or less. Traced through their extent the ridge was an irregular round-backed hill, precipitous often on the leeward side. The undulations, indeed, as to primary waves, consisted mainly of these round-backed masses, broken into or modified by innumerable secondary and smaller waves within their general body. The time in which these waves passed the ship was now, on an average, about fifteen seconds, the ship's speed being increased from nine to eleven knots, and the obliquity of the ship's course to the direction pursued by the waves was three points. On the 9th, two days after the above condition of the waves—whilst the sea yet ran high—few waves could be traced, continuously, above three hundred or four hundred yards in extent along the same ridge. The crests often curled over, but none so as to reach the height of a thirty feet wave, and broke for a wide space, estimated at fifty to one hundred yards in continuity.

Miscellaneous Notes and Suggestions.—The mode adopted in these researches of finding the *height* of waves is, I believe, quite satisfactory, and, observed with care and with relation to numbers or proportion of waves, as accurate as need be. The depression of the horizon in respect to the elevation of the observer is too small to form even a correction. As the horizon from the paddle-box $\frac{30}{2} = 15$ feet, had only a depression of 3′ 49″, the distance of the visible horizon, as seen from this elevation, would be 4·45 statute miles, and the actual depression in feet due to the distance of the summit of the wave when the ship was in the midst of the hollow, could only be 0·18 foot or 2·16 inches. Other modes of determining the width of a wave—or the extent betwixt summit and summit—much preferable to that described (the only available one I could devise) might easily be adopted where the management of the ship was in the hands of the observer. In steam ships the simplest mode for high seas, perhaps, would be, altering the speed of the ship when going in the direction of the wave or against the wave; the ratios of the time of transit of wave-crests, under different rates of sailing of the ship might yield results very close to the truth. In moderate sized waves the plan adopted by Capt. Stanley—whose observations I met with before this meeting—seem satisfactory. But in calms, or moderate weather after a storm,—that is, for the determination of the velocities of less elevated waves—a variety of processes might be available.

The author referred, in conclusion, to the *forms* of wave crests, and heights, modified by crossings, interferences, and reflections.

On Metallic Reflection; by Prof. G. G. Stokes.

The effect which is produced on plane-polarized light by reflexion at the surface of a metal shows that if the incident light be supposed to be decomposed into two streams, polarized in and perpendicularly to the plane of reflexion respectively, the *phases* as well as the intensities of the two streams are differently affected by the reflexion. It remains a question whether the phase of vibration of the stream polarized in the plane of reflexion is accelerated or retarded relative to that of the stream polarized perpendicularly to the plane of reflexion. This question was first decided by the Astronomer Royal, by means of a phenomenon relating to Newton's rings, when formed between a speculum and a glass plate. Mr. Airy's paper is published in the Cambridge Philosophical Transactions. M. Jamin has since been led to the same result, apparently by a method similar in principle to that of Mr. Airy. In repeating Mr. Airy's experiment, the author experienced considerable difficulty in observing the phenomenon. The object of the present communication was to point out an extremely easy mode of deciding the question experimentally. Light polarized at an azimuth of about 45° to the plane of reflection at the surface of the metal was transmitted, after reflexion, through a plate of Iceland spar cut perpendicular to the axis, and analyzed by a Nicols's prism. When the angle of incidence was the smallest with which the observation was practicable, on turning the Nicols's prism properly the dark cross was formed almost perfectly; but on increasing the angle of incidence, it passed into a pair of hyperbolic brushes. This modification of the rings was described and figured by Sir D. Brewster, in the Philosophical Transactions for 1830. Now, the question at issue may be immediately decided by observing in which pair of opposite quadrants it is that the brushes are formed. In this way the author was led to Mr. Airy's result, namely, that as the angle of incidence increases from zero, the phase of vibration of light polarized in the plane of incidence is *retarded* relatively to that polarized in a plane perpendicular to the plane of incidence.

On a Fictitious Displacement of Fringes of Interference; by Prof. G. G. Stokes.

The author remarked that the mode of determining the refractive index of a plate by means of the displacement of a system of interference fringes, is subject to a theoretical error, depending upon the dispersive power of the plate. It is an extremely simple consequence (as the author showed) of the circumstance that the bands are broader for the less refangible colors, that the point of symmetry, or nearest approach to symmetry, in the system of displaced fringes, is situated in advance of the position calculated in the ordinary way for rays of mean refrangibility. Since an observer has no other guide than the symmetry of the bands in fixing on the center of the system, he would thus be led to attribute to the plate a refractive index which is slightly too great. The author has illustrated this subject by the following experiment:—A set of fringes produced in the ordinary way by a flat prism were viewed through an eye-piece, and bisected by its cross wires. On viewing the whole through a prism of moderate angle, held in front of the eye-piece with its edge parallel to the fringes, an indistinct prismatic image of the wires was seen, together with a distinct set of fringes, which lay quite at one side of the cross wires, the dispersion produced by the prism having thus occasioned an apparent displacement of the fringes in the direction of the general deviation.

On the Refractive Indices of several Substances; by the Rev. Prof. Powell.

Having on former occasions endeavored to extend the list of observed indices for the standard rays of the solar spectrum given by prisms of different media, by means of an apparatus described, along with the statement of the results, in my report to the British Association, 1839, I now beg to offer to the Association the indices in like manner obtained for the four following. The rare oil of spikenard I received through a friend from the late Mr. Hatchett, by whom it was carefully prepared, perfectly pure; for the other three I am indebted to Mr. N. S. Maskelyne. The results in each case are the mean of several repetitions. In two instances (the oils of lavender and sandal wood) the absorption of the violet rays (as in so many other oils) was such as to render the line H very indistinct; its index is therefore marked as doubtful.—

MEDIUM.	μ for the the Standard Rays.						
	B	C	D	E	F	G	H
Oil of Spikenard, Temp. 22 deg. Centig.	1·4732	1·4746	1·4788	1·4829	1·4868	1·4944	1·5009
Oil of Sandal Wood, Temp. 20 deg. Centig.	1·5034	1·5058	1·5091	1·5117	1·5151	1·5231	1·5398?
Oil of Lavender, Temp. 20 deg. Centig.	1·4641	1·4658	1·4660	1·4728	1·4760	1·4837	1·4930?
Benzole, Temp. 18 deg. Centig.	1·4895	1·4961	1·4978	1·5041	1·5093	1·5206	1·5310

In my report (1839), I stated the impossibility of obtaining measures in chromate of lead from the absence of all appearance of lines, and the entire absorption of the blue and violet portion of the spectrum. I have since thought that in the absence of any determinations of the kind it might not be useless to give the very rough estimates which my former attempts enable me to obtain by means of the absorption of blue glass, which gave a point roughly corresponding to about B, another to D, and the extreme green space visible might be about E. The most refracted of the two spectra (given by the double refraction of the substance) was the worst defined, and in this the part corresponding to D is extremely uncertain. The mean of two sets of observation was as follows:—Prism of chromate of lead, axis of prism perpendicular to axis of crystal, mean angle obtained by reflexion and by measurement = 14° nearly.—

RAY.	1st Spectrum.		2nd Spectrum.	
	Δ	μ	Δ	μ
Extreme red, about B	22°	2·53	26° 30′	2·84
about D	23° 10′	2·55	29° ?	3·00 ?
about E	24° 30′	2·70	30° 30′	3·10

While upon the subject, I may be allowed to remark, that as attempts are now making, with so much promise, for procuring optical glass of a superior quality, it would be highly interesting if specimens were cut into prisms (portions of half an inch cube, or even less, will do, and two sides only need be polished, containing an angle of about 60°), so as to subject the glass to the *very delicate test of the visibility of the finer lines of the spectrum.* I have reason to think that working opticians are not generally aware that in many specimens, *apparently very clear*, only a *few* of the broader lines can be seen and *very often none;* in Fraunhofer's glass nearly six hundred were visible.

On the Magneto-optic Properties of Crystals, and the Relation of Magnetism and Diamagnetism to Molecular Arrangement; by Messrs. J. TYNDALL and HERMANN KNOBLAUCH.

During the investigation carried on more than one hundred natural crystals had been examined. The results were thus briefly summed up:—We have on the one side four new forces assumed,—the optic attractive force and the optic repulsive force, the magno-crystallic force and the magneto-crystallic force; and on the other side no new force whatever, but simply that modification of existing forces which we have named electro-polarity. By attention to the compression of amorphous bodies, every single experiment cited in proof of these four forces can be reproduced. Exactly the same can be exhibited with wax, dough, artificial layers, gutta percha and ivory. The alternative then appears to be either to explain the action of these substances by the assumption of optic and crystallic forces, or to explain magno-crystallic action by electric polarity.

This paper gave rise to a very animated discussion.—The President said, that although he was ready to admit that Mr. Tyndall's theory was most ingenious, and the arguments and experiments by which he sustained his views were apparently well conceived and sound, yet time must be given to weigh them well before a satisfactory conclusion could be reached.—Prof. Thomson thought that Mr. Tyndall's views would be found to be substantially consonant with Dr. Faraday's and the theory of Poisson.

On the Polarizing Structure of the Eye; by Sir D. Brewster.

The author said that when he sat down to this paper he was not aware that Prof. Stokes was intending to make the communication which was placed next on the list—as his was an attempt to account by the polarizing structure of the eye for the phenomena of Haidinger's brushes, which would be referred to them immediately by Mr. Stokes. He would, therefore, confine himself to showing that the eye contained within itself amply sufficient to account for the phenomenon, because constituting the eye itself an ever ready polariscope or analyzer of polarized light.—He proceeded by diagrams to show that the crystalline lens of the eye, its posterior enclosing membrane, with the concave parallel membranes immediately in front of the retina, which together acted similarly to a number of water crystals placed one within the other, constituted a polarizing apparatus, which by analyzing the polarized light from the blue sky, would give two blue skies, bounded by hyperbolic curves, with an interposed space of a yellow of the third order, or a brownish yellow, which would constitute the brushes, or bouchals, of Haidinger. One only difficulty still confronted him in this explanation, viz., that it ought to turn round the brush 45° from the plane of polarization,—in which plane, on the contrary, the brush was found to arrange itself.

On Haidinger's Brushes; by Prof. G. G. Stokes.

It is now several years since these brushes were discovered, and they have since been observed by various philosophers; but the author has not met with any observations made with a view of investigating the action of different colors in producing the brushes. The author's attention was first called to the subject by observing that a green tourmaline which polarized light very imperfectly enabled him to see the brushes distinctly, while he was unable to make them out with a brown tourmaline which transmitted a much smaller quantity of unpolarized light. He then tried the effect of combining various colored glasses with a Nicols's prism. A red glass gave no trace of brushes. A brownish yellow glass, which absorbed only a small quantity of light, rendered the brushes very indistinct. A green glass enabled the author to see the brushes rather more distinctly than they were seen in the light of the clouds viewed without a colored glass. A deep blue glass gave brushes of remarkable intensity, notwithstanding the large quantity of light absorbed. With the green and blue glasses the brushes were not colored, but simply darker than the rest of the field. To examine still further the office of the different colors in producing the brushes seen with ordinary daylight, the author used a telescope and prism, mounted for showing the fixed lines of the spectrum. The sun's light having been introduced into a darkened room through a narrow slit, it was easy, by throwing the eye-piece a little out of focus, to form a pure spectrum on a screen of white paper placed a foot or two in front of the eye-piece. On examining this spectrum with a Nicols's prism, which was suddenly turned round from time to time through about a right angle, the author found that the red and yellow did not present the least trace of brushes. The brushes began to be visible in the green, about the fixed line E of Fraunhofer. They became more distinct on passing into the blue, and were particularly strong about the line F. The author was able to trace them almost as far as the line G; and when they were no longer visible the cause appeared to be merely the feebleness of the light, not the incapacity of the greater part of the violet to produce them. With homogeneous light, the brushes, when they were formed at all, were simply darker than the rest of the field, and as might have been expected did not appear of a different tint. In the blue, where the brushes were most distinct, it appeared to the author that they were somewhat shorter than usual. These observations account at once for the color of the brushes seen with ordinary daylight. Inasmuch as no brushes are seen with the less refrangible colors, and the brushes seen with the more refrangible colors consist in the withdrawal of a certain quantity of light, the tint of the brushes ought to be made up of red, yellow, and perhaps a little green, the yellow predominating, on account of its greater brightness in the solar spectrum. The mixture would give an impure yellow, which is the color observed. The blueness of the side patches may be merely the effect of contrast, or the cause may be more deeply seated. If the total illumination perceived be independent of the brushes, the light withdrawn from the brushes must be found at their sides, which would account, independently of contrast, both for the comparative brightness and for the blue tint of the side patches. The observations with homogeneous light account likewise for a circumstance with which the author has been struck, namely, that the brushes were not visible by candle-light, which is explained by the comparative poverty of candle-light in the more refrangible rays. The brushes ought to be rendered visible by absorbing a certain quantity of the less refrangible rays, and accordingly the author found that a blue glass combined with a Nicols's prism enabled him to see the brushes very distinctly when looking at the flame of a candle. The specimen of blue glass which showed them best, which was of a tolerably deep color, gave brushes which were decidedly red, and were only comparatively dark, so that the difference of tint between the brushes and side patches was far more conspicuous than the difference of intensity. This is accounted for by the large quantity of extreme red rays which such a glass transmits. That the same glass gave red brushes with candle-light and dark brushes with daylight, is accounted for by the circumstance that the ratio which the intensity of the transmitted red rays bears to the intensity of the transmitted blue rays, is far larger with candle-light than with daylight.

On the Six Climates of France; by Dr. MARTINS.

Dr. Martins commenced by stating that France partook of the climates both of continental and sea-girt countries. He wished at present to consider six climatorial subdivisions, viz.—1. The northeast or Vosgien.—2. The northwest or Séquanien.—3. That of the west or Armoricain.—4. The southwest or Girondin.—5. The southeast or Rhodanien.—6, and finally, the Mediterranean or Provençal climate. Upon each of these subdivisions he enlarged; detailing the features of the country, the rivers, mountain-ranges, sea-coasts, geological structure, differences of level, and state of cultivation in each case, with the prevailing and most important features in the actual climate of each. Dr. Martins exhibited a map of France with these six regions distinguished. He stated that hitherto the labors of the meteorologists of France had no channel of publicity at their command, but that a journal devoted exclusively to meteorology was about to be established.

Mr. Ronalds inquired whether the state of the dew point had been attended to in this classification, as in his opinion that was one very important element.—Dr. Martins replied that it had been carefully attended to.—The Astronomer Royal inquired whether the difference of climate during the day and during the night, that of the summer as distinguished from the winter, had been attended to, as his experience led him to know that most important distinctions existed between these.—Mr. R. Russell added his testimony to the same effect; and said, that in an agricultural point of view mean temperatures were not so important as was usually supposed. Along the west coast it was now found that the maximum for the summer or ripening portion of the year was of much greater importance to the agriculturist than the mean.—Sir D. Brewster said that means were not to be neglected, for it had been well established that unless the mean rose in the season that might be characterized as the vegetating season to at least 58°, it was not found to be favorable; but of course he did not mean to say that the rising of the mean of the hot season above this, or the falling of the cold much below it, were not important and to be attended to.

On Hourly Meteorological Observations made at Thibet, at an elevation of 18,400 *feet;* by Lieut. STRACHEY, R.E.

Great interest attached to these observations from their having been made during twenty-four hours at an elevation so seldom attained by man, and quite above the clouds and most ordinary disturbing influences, and with a barometer pressure somewhere about fourteen inches of mercury. The chief result was that the curves followed very nearly the same changes as they were observed to do in the lower regions.

Col. Sykes went somewhat into detail regarding these and other observations of Lieut. Strachey, in the course of which he stated that the formula of Dr. Apjohn for the reduction of the wet and dry bulb hygrometers was found to be quite inapplicable to Indian climates; the dry bulb being lowered in its indications by the proximity of the wet, and the wet bulb collecting and retaining a wet atmosphere of its own whose temperature it gave,—not that which it would attain at the lowest were this atmosphere continually removed; one consequence of which was great discrepancy of result according to the part of a room in which it was placed.—Lieut Strachey corroborated this, and said he had found the numerical coefficients of Mr. Glaisher, which varied with the temperature, and which that gentleman had tabulated, much more applicable to Indian hygrometry.

Col. Sykes then gave a brief account of several storms of hail which had occurred in India, collected from various sources by Dr. Buist. The weight of some of these masses of ice was over fourteen pounds. Many of them under a rough external coat contained clear ice within, and with that peculiar radiated structure which he had elsewhere described. Immense aggregated masses of these great hailstones were in some places brought down from the mountain ravines by the succeeding torrents, and in one of these conglomerations a snake was found frozen up and apparently dead, but it soon thawed and revived.

On the Causes of the Rise of the Isothermal Lines in the Winters of the Northern Hemisphere; by Mr. T. Hopkins.

Mr. Hopkins examined some of the isothermal lines exhibited in the maps recently constructed by Prof. Dove, and objected to the theory which is put forward to account for the irregular rise of the winter isothermals in the northern Pacific, Atlantic and Arctic Oceans through the warming influence of the water of these oceans. But if neither the proportional extent of the surface of the sea, as compared with the land, nor the flow of a warm current of water carries high temperature to these northern latitudes, what is the cause of such temperature being found there? A reply is prepared by Prof. Dove himself, where he says,—"This surface," meaning the surface of the globe, "being a highly varied one, the sun's influence on it is also constantly varying, for the impinging solar heat is employed in raising the temperature of substances which do not change their condition of aggregation;—but when engaged in causing the melting of ice or the evaporation of water it becomes latent. When, therefore, the sun, returning from its northern declination, enters the southern signs, the increasing proportions of liquid surface upon which it shines cause a corresponding part of its heat to become latent, and hence arises the great periodical variation in the temperature of the globe which has been noticed above,"—meaning the difference of temperature of the northern and southern hemispheres. Why suppose that this effect of the evaporation of water is experienced only in the relative temperatures of the northern and southern hemispheres? And why not trace the effects of *condensation* of vapor, as well as of the *evaporation* of water? It is evident that heat is absorbed and made latent wherever vapor is produced, and it is equally clear that this heat is given out and made active wherever the vapor is condensed! It does not appear from the atmospheric currents which prevail, that any portion of the vapors of the southern hemisphere passes into the northern, to be condensed within or near to the basin of the Pacific, and there is no reason to suppose that it does;—but in the basin of the Atlantic it is sufficiently evident that vapor does not so pass. The vapor which passes over the Northern Atlantic, and is condensed beyond the British Isles and Norway, is supplied from the tropical and other seas north of the equator. The West Indies constitute the principal point of departure of this vapor, and in the month of January it is carried by southwestern and western winds to those localities where the isothermal lines advance farthest towards the pole. It is accordingly to the condensation of this vapor, and not to the neighborhood of the Atlantic Ocean, in the latitude that we are to attribute the high temperature of this part of the world in the winter. The Atlantic Ocean is as near to Labrador as to Norway, but there is little condensation on the coast of the former, whilst there is much about the latter. Indeed, as far as we know, condensation of vapor is the only influence that operates exclusively on the eastern coasts of the two oceans, the Pacific and the Atlantic, and therefore to it we may attribute the warming of the localities, particularly in the Arctic Ocean, as indicated by the isothermal lines. Condensation, we know, furnishes a constant and abundant supply of heat, not like diffusion by contact, nor radiation from surfaces nearly equal in temperature, but by the energetic chemical action which converts an aeriform substance into a liquid, and consequently changes the heat from a latent to an active state. The greatest irregular rise in the isothermal lines is found in the winter of the northern hemisphere, just at the time that the condensation of vapor produces the greatest effect on the temperature of the air; and the temperature rises most along that line or stripe where the largest amount of condensation takes place; and in that locality the same temperature reaches the highest latitude, showing that condensation of vapor is the cause of the rise of the isothermal lines in the parts.

On the Argument for the Physical Connection of Double Stars, deduced from the Theory of Probabilities; by Prof. FORBES.

The author read a passage from Herschel's 'Outlines of Astronomy,' where this argument is set forth. Mitchell, in the year 1767, in a paper in the Philosophical Transactions, was the first who advanced this argument. He calculates the odds as 500,000 to 1 against the stars which compose the group of the Pleiades being fortuitously concentrated within the space they occupy, and thence infers the probability of some physical connection between them. Struve has pushed this argument much further. In his classification of double stars he has applied it to estimate the improbability of the occurrence of even double stars in close proximity. He calculates the odds as 9,570 to 1 against any two stars from the first to the seventh magnitude falling, if fortuitously scattered, within 4″ of one another. The number of such binary combinations actually observed at the date of the calculations, was 91, and more have since been added to the list. Again, he calculates the odds against any two stars of a number fortuitously scattered, falling within 32″ of a third, so as to form a triple star, as not less than 173,000 to 1, while four such triple stars were known to exist. The conclusion, adds Sir John Herschel, of a physical connection of some kind or other is, therefore, unavoidable. Against the principle of this argument, Prof. Forbes, though with much diffidence, felt himself called on to protest. He owned he could not attach any idea to what would be the distribution of stars, or of any thing else if "fortuitously scattered," and therefore he must regard with hesitation, if not doubt, an attempt to assign a numerical value to the antecedent probability of any given arrangement or grouping whatever. To him it appeared that an equable spacing of the stars over the sky would seem to be far more inconsistent with a total absence of law or principle than the existence of spaces of comparative condensation, including binary or even more numerous groups, as well as regions of great paucity of stars. As an illustration of this, he adduced the representation of stars and their grouping by sprinkling viscid white paint from a coarse brush upon a dark ground; by which, although it was impossible to conceive a nearer approach to "random scattering," yet he had witnessed the production by it of an artificial galaxy, presenting every variety of grouping with double and triple points innumerable; nor could he conceive how on any reasonable theory of chance it should be otherwise.

On Cometary Physics; by Prof. SMYTH.

The author said that points in the Physics of Comets which he had intended to bring in detail under the notice of the Section, might be comprehended in the twelve following axioms or aphorisms—viz. 1. A comet consists of a nucleus and one or more gaseous envelops. 2. The nucleus if solid and material is extremely small. 3. This nucleus is excentrically situated in the gaseous envelop. 4. Comets of longest periods have the largest bodies. 5. The more excentric the orbit of a comet the more excentric is the body of the comet. 6. A comet revolves round its shortest nucleoid axis in the time it revolves round the sun. 7. This axis is not always at right angles to the plane of the orbit. 8. There is also a quicker rotation round its longer axis. 9. A comet shines by reflected light, and shows a sensible phase. 10. In proportion to the excentricity of its orbit a comet increases in density, and decreases in size in approaching perihelion, and *vice versâ*. 11. The longer axis of a comet is straight at perihelion and aphelion; but between these is concave towards the aphelion, the curvature being nearly proportioned to the excentricity of the orbit. 12. (Sir J. Herschel.) The component molecules of a comet are held together only by their mutual gravitation, each constituting almost a separate projectile, and describing its own orbit round the sun.—In consequence of the great press of business before the Section the author confined himself to the illustration of the 9th and 10th of these axioms in connection with the 12th,—showing by diagrams, how the changing appearances both of the head, the nucleus, and the tail, as it swept past perihelion, and particularly the forking observed in the tails of some comets, were simple effects of phase arising from the changing relative position of the illuminating sun, the comet and the observer. The 10th he illustrated by showing that towards perihelion the several parabolic paths of the parts of the comet, by becoming crowded together, caused the condensation of the comet, while the contrary took place by the separation of these several orbits towards aphelion. The author exemplified these principles by reference to the great comet of 1845, which, though visible to the naked eye for about three weeks, and to the telescope for more than five, yet in the very short time of less than twenty-four hours swept through that part of its perihelion path cut off by a plane through the sun parallel to the ecliptic, having approached within about 60,000 miles of the sun:—the nearest approach to that luminary ever actually observed.

Mr. Rankine observed, that if the 12th axiom (attributed to Sir J. Herschel) were a correct representation of facts, he conceived that it would follow that the tail of a comet, which was known to be turned straight from the sun at perihelion, must be turned straight towards the sun at aphelion; and at other parts of the orbit must have intermediate positions. This he proceeded to illustrate by a diagram, in which a number of ellipses with the same major axis were so arranged, respecting the sun occupying a focus common to all, as that their perihelia might all be ranged in one line, embracing the sun also.—Prof. Smyth did not concur in Mr. Rankine's argument; though time would not now admit of his going farther into it than to remark, that in the history of comets no fact was better established than that their tails were always turned, though with a slight curvature, directly from the sun; that this fact was well known to Sir J. Herschel, and was one basis of his induction.

On a new Membrane investing the Crystalline Lens; by Sir D. Brewster.

The author drew a diagram representing the crystalline lens of an ox with its inverted capsule; and said that having lately had occasion to examine the crystalline lens of an ox, which had been killed the day before, he had put it into water,—by imbibing which it had soon swelled, and at length the capsule burst. Before it had burst, however, he had observed distinctly a membrane not before recognized by anatomists, which had at one part detached itself from the body of the lens which it manifestly invested, and risen up within and towards the capsule at one spot.

On some Phenomena of the Polarization of the Atmosphere; by Sir D. Brewster.

The author stated that by the aid of a polariscope, which he had formerly described, formed with two wedges of rock crystal cut in a peculiar way, he was enabled to determine, by an examination of the parallel bands, the neutral points of the sky, and the plane of polarization. This he illustrated by a diagram; and added, that he had now convinced himself that not only was the light from the blue sky polarized by reflection in one plane, but under certain circumstances the refraction caused by some of the clouds polarized the light in quite a different plane; and he had actually in this instrument observed clouds by the action they exerted on the light, which were quite imperceptible to the eye unassisted by it.

Prof. Stokes observed that heretofore it had been universally supposed that the clouds always exerted a depolarizing action on the light which they reflected or transmitted to the eye.

On the Dynactinometer; by Mr. Claudet.

In the introductory portion, the author insisted on the very great importance of distinguishing between the optical foci of the lenses used in photographic cameras and the foci of the photogenic rays. He said that ignorance of this distinction, or inattention to it, was the source of one of the greatest defects in photographic pictures. He had invented a simple instrument, which was exhibited and explained, for accurately distancing the object to be depicted and determining the corresponding foci of the photogenic rays in any given camera. It consisted of a number of marked sectors arranged in a spiral order at several equal distances along a cylinder supported in a frame. By placing this before a photographic camera, the sector of which the image was most distinct could be at once seen, and this determined the distance at which the object should be placed in front of the camera. Since he had invented this, he had found that there was a proper time for exposing an object on a given day, and under given circumstances, before the camera; and that a longer or shorter time than this was injurious to the effect. To ascertain readily this proper time, he had invented the dynactinometer, which he now exhibited. It consisted of a square frame of card, with a circle of card capable of being turned round either by hand or by clock-work; in one position of this circle, the whole surface of the frame exposed to the camera at the proper photogenic distance was black; but as the circle turned, a neatly divided sector of white card was exposed, and by causing the circle to turn so as to expose a given number of divisions each successive equal number of seconds, the part of the sector whose image was most clearly defined on examination of the photogenic drawing, gave the number of seconds best for exposing the object to the camera. But as the several photogenic plates were not equally sensitive, the sensitiveness of the plates was determined by placing them in a small frame, and allowing them to descend along an inclined plane, during a certain part of which descent small circular spots were exposed to the action of light, the rest being quite protected. The action of the light on these spots gave a ready and exact means of comparing the sensitiveness of the several plates.

Attempt to explain the occasional distinct vision of rapidly revolving colored sectors; by Prof. Stevelly.

He exhibited an instrument for whirling cards with colored sectors on them, devised by Mr. Grattan, of Belfast, to teach his children the effect of combining colors. He had shown this at the Natural History Society with an application for enabling painters to determine, experimentally, the exact mixture of any number of colors, and their relative proportion to produce the exact effect which they required. This apparatus he had lent to Prof. Stevelly to show his class; and while doing so, he was surprised to observe that while the cards were revolving rapidly, if he suddenly turned away his head he caught a distinct view of the individual colored sectors at the instant he was losing sight of them by a side view. A few weeks before this, he had attended the lectures of Prof. Carlile, of the Queen's College, Belfast, on the anatomy of the eye and of the ear; and had then become acquainted with a fact connected with the arrangement of the optic nerves and their relation to the retina, which seemed to him to afford an explanation of this curious fact. The optic nerve which originated in the right side of the brain, crossed over to the left eye, but on entering that eyeball only spread out into that part of the retina which spread over the portion of the eyeball next the nose, and the similar portion of the retina of the right eye was supplied by the optic nerve which sprang from the left side of the brain. These nerves, however, were united in their action by a commissure nerve, which stretched in an arch from one to the other. The other and larger portion of the retina of each eye, and that on which the images of objects as usually seen were depicted, was formed by nerves which sprang from the brain in each case on the side next the eye to which they went; these, after accompanying the optic nerve of the other eye to the place where it crossed the optic nerve going to its own eye, turned round with a bend and accompanied it in its passage into the eyeball. These portions of the retina of the different eyes were also united into one nervous action by the "commissure of the retina." So that, the retina of each eye was divided into two portions,—the portion next the nose, and the outer and larger portion; and these two portions of each eye were supplied by nerves springing from opposite sides of the brain, and not united in their action by any commissure or connecting nerve. Now, the consequence of the sudden turn of the head was, to throw the image from its usual place on to the portion of the retina next the nose, affecting a new and fresh part of the retina for an instant only,—for the motion of the head instantly interposed the socket of the eye and shut off the object. The sectors therefore became distinct at that instant, for a similar reason that in the beautiful experiment of Prof. Wheatstone the electric spark showed them distinct,—namely, the instantaneousness of the impression.

The following are the titles of other memoirs presented to the Section of Mathematical and Physical Science.—

Report on the observations and experiments at the Kew Observatory; by F. Ronalds.

Report on Luminous Meteors; by the Rev. B. Powell.

On the Laws of Elasticity of Solids; by W. J. Macquorn Rankine.

Notice of the working of the new Integrating Anemometer during the past year; by Mr. Follet Osler.

On Magnetic Forces; by Mr. J. A. Broun.

On the construction of the Silk Suspension Threads for the Declination Magnetometer; by Mr. J. A. Broun.

On the Mechanical Compensations for the effect of Temperature on the Bifilar and Balance Magnets; by Mr. J. A. Broun.

On some Phenomena of Mirage on the east Coast of Forfarshire; by Rev. C. F. Lyon.

Experiments on the Expansion of Glass, Woods, and Metals from changes of Temperature; by Mr. Roberts.

Report of the committee on the Instruments for the measurement of earthquake waves; by Mr. Mallet.

Report on the Meteorology of the Azores; by Mr. J. C. Hunt.

Report on the effect of a stroke of lightning on a tree near Edinburgh; by Prof. PHILLIPS.

On the climate of the valley of the Nile; by Mr. T. S. WELLS.

On the means of computing the quantities of Aqueous vapor in the Atmosphere at various places and heights; by Mr. T. HOPKINS.

On the daily formation of Clouds at Makerstoun; by Mr. T. HOPKINS.

On the passage of Storms across the British Islands; by Mr. R. RUSSELL.

On remarkable Thermometrical Maxima at or near the Moon's first quarter, from 1839 to 1850; by Mr. R. EDMONDS.

On some extraordinary electrical appearances observed at Manchester on the 16th of July, 1850; by Mr. P. CLARKE.

On Meteorological Phenomena at Huggate, Yorkshire; by Rev. T. RANKINE.

On Isoclinal Magnetic Lines in Yorkshire; by Prof. PHILLIPS.

On a question of Probabilities which occur in the use of a fixed collimator for the verification of the constancy of Position of an Azimuth Circle; by Prof. AIRY.

On the Lunar Surface, and its relation to that of the Earth; by Mr. NASMYTH.

On a Tissue woven by Caterpillars; by J. DENNISTOUN.

On a new solid Eye-piece; by the Rev. J. B. READE.

On Polygons inscribed on a Surface of the Second order; by Sir W. R. HAMILTON.

On the Theory of Magnetic Induction; by Prof. THOMSON.

On the reduced observations for six years of the Winds in the regions of Glasgow; by Prof. NICOL.

On some powerful Magnets made by a process devised by M. Elias, and manufactured by M. Logeman, optician, at Haerlem; by Sir D. BREWSTER.

On the Optical Properties of Cyanuret of Magnesia and Platina; by Sir D. BREWSTER.

On a Geometrical Rotation between Ten Points, on a surface of the second order; by Sir W. R. HAMILTON.

On the mode of Disappearance of Newton's Rings in passing the Angle of total internal Reflexion; by Prof G. G. STOKES.

On the Distribution of Shooting Stars in the Interplanetary Spaces; by Mr. H. HENESSY.

On Electrical Figures of Dust on Plate Glass; by Mr. J. A. BROUN.

Magnetic Chart, exhibited by Mr. BESWICK.

Section B.—CHEMISTRY, INCLUDING ITS APPLICATIONS TO AGRICULTURE AND THE ARTS.

On the per-centage of Nitrogen as an Index to the nutritive Value of Food; by Dr. A. VOELCKER.

The object of this paper was to show, that the usual estimation of the nutritive qualities of an article of food is frequently attended with inaccuracies, which renders it desirable to modify our present methods in this respect in many cases. A circumstance which leads to considerable error is, the presence of ammoniacal salts in the juices of plants. In order to prove experimentally the presence of ammoniacal salts in larger quantities than hitherto suspected, and to avoid the objection that they might result from a partial decomposition of albuminous substances during the analysis, the author chose fungi for his experiments, which are rich in nitrogen and known as being highly nutritious. The species used was *Agaricus prunellus*, a species which is edible, and remarkable for forming most beautiful fairy rings. After having separated all soluble proteine compounds by means of basic acetate of lead, which re-agent throws down these completely, the amount of nitrogen still present in the juice of these agarics, in the form of ammoniacal salts, was found to be 0·204 per cent. for the fresh fungi, or 1·82 per cent. for the dry fungi. The whole amount of nitrogen in the same agarics, collected at the same time, determined by combustion, was found to be 0·74 per cent. for the fresh fungi, or 6·61 per cent. for the fungi dried at 212° F. Deducting from the last stated numbers the quantity of nitrogen found to exist in the juice in the form of ammonia, we find that only 0·536 per cent. of nitrogen in the fresh, or 4·799 per cent. of nitrogen in the dry fungi, exists in the state of proteine compounds, and that nearly one third of the nitrogen obtained by direct combustion exists in the form of ammonia in the juice, or at all events in a form in which the nitrogen adds nothing to the nutritive value of the fungi. The nutritive value of the fungi has thus been overrated considerably; and there can be little doubt that the same is the case of many vegetables, which according to the author's experiments contain sometimes considerable quantities of ammonia in the form of ammoniacal salts.

Dr. Christison remarked that he had long been convinced that there was a considerable fallacy in the methods of determining the value of nitrogen, and he hoped Dr. Voelcker's communication would give inquiry a more satisfactory direction.—Dr. Daubeny made some observations on this paper; and particularly noticed the researches of Prof. Hoffman on the substitution of ammonia, or of its elements, for carbon, which it appeared to him pointed to some laws in connection with the process of assimilation of nitrogenous materials by growing vegetables.—Dr. R. D. Thomson offered some objections to the reception of the doctrine that nitrogen was the principal source of nutrition, since it is found that blood and the other animal constituents contain many other substances.—Dr. L. Playfair was pleased that Dr. Voelcker had pointed out a source of error in the determination of nitrogen. Having been engaged in examining the dietaries of a large number of extensive establishments, he should lay the results before the Meeting.

On a peculiar form produced in a Diamond when under the influence of the Voltaic Arc; by J. P. GASSIOT.

M. Jaquelin was the first to show that when the diamond is submitted to the high temperature and influence of the voltaic arc, it quickly becomes converted into a black carbonaceous matter having all the appearance of coke:—the diamond when in a native state is an insulator or non-conductor of electricity, but when thus changed into coke it becomes an excellent conductor. At the Chemical Section of the British Association, held at Oxford, in 1847, Dr. Faraday exhibited some specimens of the diamond coke which had been forwarded to him by M. Jaquelin, and subsequently, on the 16th of June, 1848, he publicly showed the experiment in London, in the theatre of the Royal Institution. On repeating the experiment a short time since before a few friends, I obtained a product so totally different from that of M. Jaquelin, that I am induced to bring the subject before this Section, in the anticipation that it may tend to elicit some observations on a phenomenon which at the time attracted the attention of many electricians. The apparatus I used in the experiment consisted of forty series of the usual size of Grove's nitric acid battery; the terminals were made from two pieces of well burnt box-wood charcoal, that attached to the positive or platinum end of the battery being formed in the shape of a small cup or crucible, in which the diamond was placed; to the negative or zinc end of the battery, a piece of the same charcoal (but *pointed*) was attached. The experiment was then made in the same form as described by M. Jaquelin, by first making contact with the two charcoal terminals, then bringing the flame in such a position as to cause it to *surround* the diamond;—in less than one minute, the diamond as well as the electrode became in a state of intense ignition. The diamond gradually increased in size, rolling about in the heated crucible; when it suddenly expanded, forcing itself upwards on the negative terminal, at which moment I separated the electrodes. The diamond, which was in a state of intense ignition, remained attached to the negative terminal. When cool it exhibited the same state as it now presents. It was expanded to eight or ten times its original bulk. Instead of becoming a black carbonaceous substance, and a good conductor, it has a vitreous white opaque appearance, and remains a non-conductor. It has also a deep circular cavity on that portion which was opposite and nearest to the positive electrode; that part which was in contact with the negative electrode being clearly discernible by a small portion of the box-wood charcoal remaining attached to it. The centre of the cavity appears to be still brilliant, as if that portion of the diamond had not been in a complete state of fusion. In one or two other experiments the diamonds disintegrated, the fragments remaining in a carbonaceous state. Since which I have not had an opportunity of repeating the experiment.

Report on the present State of our Knowledge of the Chemical Action of the Solar Radiations; by Mr. R. HUNT.

In this report the author gave an historical sketch of the progress of inquiry on this subject, from the period when Scheele first observed that the chlorid of silver was blackened much more speedily by the rays at the blue end of the spectrum than by those at the least refrangible, or red end, to the announcement of the discovery of the sensibility of the iodized tablets to the solar influences by Daguerre and the discovery of the action of gallic acid in the Calotype process by Mr. Fox Talbot. He then proceeded to show the extent of knowledge we had obtained as to the peculiarities of the phenomena, which may be summed up as follows. The chemical action of the sun's rays is proved, by its influence on organic and inorganic bodies, to extend over all the luminous rays of the prismatic spectrum—and slightly beyond them at the least refrangible end, and considerably beyond them at the most refrangible extremity. Living organisms and the products of organic life appear to be influenced by light—the luminous power—as distinguished from the purely chemical or calorific powers. The vitality of plants is stimulated by light; and although many functions are performed in the absence of luminous radiations, they all appear to be quickened by its exciting powers; at the same time we have evidence to show that the chemical principle is necessary to the processes of assimilation, and consequently to the production of many of the proximate constituents of plants. The author is of opinion—though he regards the subject as open to serious inquiry—that the processes of germination and budding are essentially influenced by the chemical principle, *Actinism*:—that the decomposition of carbon is peculiarly due to the luminous principle;

and hence that the formation of wood in plants is a function of their vitality excited by *Light*:—that the development of the flower is due to a delicate balance of the forces, *Actinism* and *Light*, since we find that both the luminous and chemical agencies are very active during the process, and that the ripening of fruit and the perfecting of the healthful conditions of the seed are due to a combination of the calorific and chemical forces—as evidenced in the so-called parathermic rays, —many of the properties of which have been examined by Sir John Herschel and Mrs. Somerville. Returning to the consideration of the influence of the solar rays upon inorganic bodies, the author thought it established beyond a doubt—1st. That the maximum of chemical (actinic) phenomena was to be found where there was the least quantity of light and heat.—2. That as the luminous power increased—either in the spectrum or in natural phenomena—the chemical (actinic power) diminished, until it came to its minimum, where light—luminous power—existed at its maximum.—3d. That although the chemical influence extended to the red or heat-giving rays, its operations were materially modified, and to all appearance changed, by the combined operation of the calorific power, and that results standing in direct opposition to those obtained by the pure chemical rays were given by the chemico-calorific rays. In conclusion, the author pointed out the wide field for investigation which was opening to the experimentalist, and he showed that, although much had been achieved by the experiments already undertaken, there yet remained an extensive ground for inquiry which may be considered as absolutely unbroken:—chemical action, vital power, electrical phenomena and phosphorescence were proved to be directly dependent on the solar influences; but we yet want the researches which shall satisfactorily show whether these phenomena are due to one great principle modified by the matter on which it acts, or whether they result from the operation of forces combined in action, although very different in their resulting effects.

New Researches on the Conductibility of the Earth; by Prof. MATTEUCCI.

Although the good conducting power of the earth is at present generally admitted and is advantageously applied to the construction of electric telegraphs, it must be confessed that nothing has been hitherto known of the laws and theory of this singular phenomenon. In England, Germany, and Russia, it has been found advisable, for several years past, to form the telegraphic circuit partly with the earth and partly with the metallic wire, instead of forming the whole circuit with metallic wire only. I was, I believe, the first to show, by exact experiments made in 1844 at Pisa, and by others performed according to my propositions at the Scientific Congress of Milan, that *the resistance of the earth* to the passage of the electrical current, which is sensible in short distances, ceases to increase and remains constant when the distance between the electrodes plunged in the earth has attained a certain length. Having laterally renewed my studies on this subject, I have confirmed and extended in a complete and general manner the conclusions drawn from my former researches; I have also demonstrated the principal result, given above, by different experimental processes. I have compared the resistance of a mixed telegraphic circuit with that of an entirely metallic circuit, containing a length of wire twice as great as that employed in a mixed circuit. I have also formed metallic circuits of very fine brass wires, having the same resistance as the metallic portion of the very long mixed telegraphic circuit; and finally, by making use of long metal wires covered with gutta percha, I have been able to compare the resistance of an entirely metallic circuit with that of a mixed circuit, in which the metallic portion remained constantly the same, and to which were added different lengths of earth. The following are the principal conclusions drawn from experiments which have occupied me for about a year.—The resistance of a layer of earth to the passage of the electrical current varies according to the quantity of water contained in the earth of which it is composed, —according to the specific gravity of that earth,—according to its depth beneath the surface,—according to the nature of the electrodes and extent of their surface. This resistance does not increase with the increased length of the layer of earth; on the contrary, beyond a certain limit of length, which varies according to the different circumstances just indicated, but which in all cases is of little extent, the resistance of a layer of earth *remains constant* whatever be its length. It is unnecessary to say that I could not prove this fact by experiment on circuits exceeding eighty miles in length, such being the average of the telegraphic circuits in Tuscany. In making the experiment near the surface of the soil, it is difficult to plunge the electrodes in earth of exactly the same conducting power; different portions of the surface of soil possessing either better or worse conductibility than that on which I began to operate, it follows that in increasing the distance between the electrodes we may find either an increase or diminution in the resistance of the earth. Likewise, in operating on a long mixed telegraphic circuit, which is not perfectly isolated, owing to the effect of the different derived circuits formed between the posts and the earth, the electric current is stronger near the piles than at a distance, and stronger than in a circuit which is formed only of metal wire equal in length to that which enters into the mixed circuit. This explains the results which I had obtained from my former uncompleted experiments. The resistance of a layer of earth appears to diminish as its length increases only in cases where we meet with other layers of better conducting power. In every layer of earth of a certain *constant* conducting power, the resistance which at first increases very feebly with the increased length of the layer, becomes very soon constant, and continues the same for all the subsequent lengths, however great, on which experiments have been made. Now, it is evident that as the increase of resistance in a long metallic circuit is scarcely perceptible when we add to the circuit, by means of two large electrodes, a thin stratum of water; so we ought to find in the long mixed telegraphic circuits that the resistance of the earth is null or nearly so, since it is equal to that of a thin stratum of water of a very large section. The law of the conducting power of the earth being established, it remains to give the theory of this phenomenon. The opinion of the scientific world is divided on this point. Some explain the good conducting power of the earth by the almost infinite section of the earth compared with the distance of the electrodes; others, again suppose that the electricities at the extremities of the pile are dissipated in the earth, in the same manner as the electricity of the conductor of an electrical machine. This second explanation, will not bear the slightest examination, nor can it be made to tally with the results of the most elementary experiments relative to the conducting power of the earth. In fact, we cannot on this supposition explain why the resistance of the earth increases at first with the length of the layer; why it varies with the depth and the degree of moisture of that layer; why it changes if the mass of earth interposed between the two electrodes happen to decrease or to be wanting, as I have proved by experiments made in mountainous districts; why the interposition of a portion of earth of a different conducting power produces a variation in the resistance of the entire mass; why this resistance becomes infinitely greater when we keep this layer in a wooden trough separate from the earth, but in communication with it by means of large metallic plates. Finally, according to this explanation, the resistance of the metallic part of a mixed circuit ought to disappear,—a thing which never happens. I think that I may be able to give a satisfactory explanation of the good conducting power of the earth, founding my assertions on very simple experiments and on theoretical views already known. As long ago as 1837, I proved in a memoir published in the *Annales de Physique et de Chimie*, that in operating on a certain liquid mass, very considerable compared with the distance of the electrodes plunged in it, *the length of the intermediate liquid stratum has no sensible influence on the intensity of the current.* I have recently verified this result on a very large scale. I had a wooden case made seven metres in the side. I keep this case isolated from the earth, and filled with water. Operating on this mass of water, we find that the resistance of a certain stratum of water, variable within certain limits, is independent of its length. In like manner, in studying the conducting power of spherical masses of water varying in diameter from $2^{c \cdot m}$ to 30 or $40^{c \cdot m}$, I have found that the resistance of these spherical masses of water was the same, and independent of their diameter. I have already said that this result may be deduced from the theory, and this is done as follows:—From the same differential equations given first of all by Fourier in his celebrated theory of heat, and which Ohm has applied to electricity, suppressing in the latter case the terms which expressed the dispersion of heat in the air, are deduced in the case of the sphere the results which I have obtained by experiments on the propagation of electricity in the earth. Although we are as yet ignorant of the physical value of that variable U which figures in the fundamental equation of Ohm at three partial differentials, which is the same as that of Fourier in the propagation of heat, and although that equation would really be more applicable to the case of the metallic wire which communicates at one extremity with the conductor of an electrical machine in action, and at the other extremity with the earth, than to the case of the electrical current defined by its electro-chemical, and electro-magnetical action; it is no less true that a certain number of the phenomena of the electrical circuit are explained by representing the propagation of the electrical current by the same equation given by Fourier in his theory of heat. Among these phenomena, may be placed the fundamental law of the propagation of electricity in metallic wires according to their section and length, and the other more general cases of the propagation of the electrical current, and of derivation, in large metallic plates, or in spherical masses and in the earth, such as they have been found by MM. Kirchhoff and Smaaeen in Germany, and in Italy by my friends Ridolfi and Felici.

The reading of the communication from Prof. Matteucci led to a conversation on the various methods employed by the Electric Telegraph Company and others, and on the question of the investigations of Messrs. Bain and Wheatstone in England, and several experimentalists on the continent prior to these investigations of M. Matteucci as to the power of the earth to conduct electricity.—Mr. R. Hunt explained that in speaking of the conductibility of the earth it should be distinctly understood that the water contained in the superficial stratum is the conducting medium; since he has proved that non-metalliferous rocks and dry earth will not conduct an electric current.

On the Sugar Produce of the South of Spain, chiefly in connection with the employment of the Acetate of Lead and Sulphurous Acid as purifying agents; by Dr. SCOFFERN.

On the southern coast of Spain, in a region limited by Almeria on the east and Malaga on the west, bounded on the north by mountain ranges and on the south by the Mediterranean, is a tract of land which, so far as its climate and productions are concerned, may be aptly denominated tropical. In it, the date, palm, indigo, cotton, and sugar-cane flourish with vigor, yielding products equal both in quantity and quality to those of the tropics themselves. The sugar-cane, first introduced by the Arab conquerors, is not only consumed in large quantities as a dessert, but also gives rise to a considerable manufacture of raw and refined sugar, a circumstance which beyond Spain itself seems to be very little known. There is perhaps no example on record of any operation involving a commercial result attended with such an enormous destruction of materials as the operation of extracting sugar from the cane. One portion of this loss is due to mechanical, another to chemical causes. The sugar-cane has been stated by most writers who have found opportunities of practically examining the subject to contain no more than 10 per cent. of solid non-saccharine matter, leaving 90 per cent. of juice to be extracted. Of this 90 per cent., most writers concur in testifying that in practice scarcely 50 per cent. are actually obtained; at least in the British West India possessions. Cane juice itself has usually been stated to contain from 17 to 23 per cent. of crystalline sugar, of which scarcely 7 per cent. in practice is actually extracted. Considerable doubts having been expressed as to these statements of the amount of juice in the cane, and sugar in the juice, I have lately gone through a series of experiments having for their object the settlement of the doubt, and with the result of amply confirming the testimony of other experimenters. Having operated on canes from various parts of this district, by slicing them, exhausting first by hot water and then by hot alcohol, and finally drying, I obtained as my mean result about 10 per cent. of woody or insoluble matter; whilst the sugar extracted and crystallized ranged from 17 to 23 per cent., as had previously been stated. It would consequently appear that 40 per cent. of juice is actually lost in the practice of our West India workings; and now arises, as a most important consideration, the question as to what extent this loss is inevitable, and to what extent it might have been obviated by altered machinery or improved manipulation. Instead of 50 per cent. of juice extracted, 70 per cent. is much nearer the average amount yielded by the sugar-mills of this coast, although occasionally the result is as high as 75 per cent., and this, in some cases, with mills of very inferior construction. The cane, however, is passed between the rollers of the mill four times, until the refuse or megass, as the pressed cane is called, has been reduced to a state of disaggregation resembling ground tan, whereas the West India cane refuse is represented to be in the form of long strings, a sufficient proof that the pressure applied has been very inadequate. After the cane has finally left the mill, it is immediately, in the Spanish sugar regions, subjected to the operation of pressing, sometimes by the agency of a screw, but in many cases by hydrostatic force. By the latter method, I have seen 13 per cent. of juice extracted from megass which had already yielded up 73 per cent. of juice to the mill, thus elevating the total quantity extracted to 86 per cent. out of the original 90, and consequently as a manufacturing operation leaving very little more to be desired. The hydrostatic press I consider to be an apparatus which is indispensable to the economy of every sugar estate:—not only does it largely contribute to the amount of juice extracted,—but what is most remarkable, the juice resulting from hydrostatic pressure of megass is invariably, so far as my observations have gone, richer in sugar than juice yielded by the mill,—a fact which seems to be only explicable on the supposition that the hydrostatic press in virtue of its great power is enabled to extrude those particles of sugar which microscopic examination demonstrates to exist in the cane in the solid and crystalline form. The subsequent stages of the sugar manufacture as carried on in Spain do not materially differ from those in operation in Cuba, and many other tropical countries. The juice is defecated or purified by lime, skimmed, evaporated to the requisite degree, and poured into earthen ware moulds, the contents of which are finally exposed to the operation of claying. In one manufactory, however, witnessed by me at Almunecar, lime is no longer used on account of its well-known injurious effects on sugar:—no other agent having been substituted in its stead, but sole reliance being placed on the coagulation by heat of albuminous matters present in the juice, and their final removal by skimming. Under this system of manufacture, the sugar produced is light colored, but badly grained, and the unseparated albuminous matters are present in such quantity that every 100 parts of the concentrated saccharine juice as it comes from the teache, or last evaporating pan, yield only 40 parts of crystallized sugar on cooling, the other 60 per cent. remaining in the condition of molasses perfectly uncrystallizable until some adequate means for defecation be had recourse to. The chief object of my residence in this sugar district was to superintend the erection of machinery for manufacturing sugar by means of my own process. The site of our operations is Montril, about forty-five miles south of Granada, in a manufactory furnished with apparatus of the rudest character. Up to this period (July 9) our own vacuum apparatus has not been sufficiently advanced to enable us to pursue our operations by its aid; nevertheless, owing to the superior defecating power of the subacetate of lead, we have, even with the old and rude machinery, obtained a result of more than 16 instead of 7 per cent. of sugar. Our striking teaches, or final evaporating pans, we were under the necessity of removing in order to afford the requisite space for our own machinery; hence we were reduced to the necessity of concluding our process of concentration in a brass pan of conical form and holding about 600 imperial gallons, thus materially increasing the difficulty of the evaporative process. Hitherto only one-sixth per cent. on the juice of sub-acetate has been used,—but I imagine the quantity may be advantageously increased. As filtration is indispensable for the conducting of this process, considerable fear was entertained lest fermentation might supervene. This fear, however, practice has demonstrated to be groundless, inasmuch as we possess in sulphurous acid an agent most antagonistic to fermentation. Another speculative fear was lest danger might arise from the lead employed: this fear, too, practice demonstrates to be entirely without foundation, for not only is the sulphite of lead most easily removed,—but even were it to remain no injury could supervene, inasmuch as this agent is as harmless as chalk.

In continuation:—Observations on the Sulphite of Lead were made by Dr. GREGORY,—who stated that he had made experiments on the sulphite of lead formed in this process. He admitted that an infinitely small portion might still remain in the sugar, but that he considered it quite innocuous. He had indeed fed rabbits and dogs with food which had been united with this sulphite of lead, and the result was that they thrived amazingly, showing no symptom of any of the known effects of lead. Dr. Gregory also remarked that in testing sugar for lead with the hydro-sulphuret of ammonia, iron was often mistaken for the former metal.

Dr. CHRISTISON contended that we had no evidence that the sulphite of lead was innocuous. It was true that in case of poisoning by carbonate of lead sulphuric acid was administered to convert it into the comparatively insoluble sulphate; but this was a case widely different from the slow accumulation of lead upon the system. Dr. Christison adduced some examples of exceedingly small doses of lead being taken in water for more than twelve months before its evil effects became apparent. He, therefore, thought it yet remained to be proved that the sulphite of lead was without action on the system, since we know nothing of the influences of the solvents it would meet with in the system, or of the influences of vital action. Rabbits, he was prepared to say, should be entirely rejected in these inquiries, since he had found that they were not affected by many poisons. Dogs and cats were the only animals which could, from their internal structure, be regarded as the representatives of the human system in these investigations.

On the Air and Water in Towns, and the action of Porous Strata on Water and Organic Matter; by Dr. R. A. SMITH.

It is a matter of great importance to find from what source it is best to obtain water for large towns, and how it is to be collected. To these points Dr. Smith particularly directs attention. Regarding the conditions of many springs, which never become muddy, but possess a constant brilliancy and a very equal temperature at all seasons of the year, the author thinks that there is a purifying and cooling action going on beneath. The surface water from the same place, even if filtered, has not the same brilliancy; it has not the same freedom from organic matter, neither is it equally charged with carbonic acid or oxygen gas,—there are other influences therefore at work. The rain which falls has not the purity, although it comes directly from the clouds; it may even be wanting in cleanness, as is often the case. Springs rise through a great extent of soil, and collect a considerable amount of inorganic salts; and it is shown by Dr. Smith that their purity is due entirely to the power of the soil to separate all organic matter, and at the same time to compel the mixture of carbonic acid and oxygen. The amount of organic matter removed in this way is surprising, and it is a most important and valuable property of the soil. The change even takes place close to cess-pools and sewers; at a very short distance from the most offensive organic matter there may be found water having little or none in it. As an agent for purifying towns, this oxydation of organic matter is the most extraordinary, and we find the soil of towns which have been inhabited for centuries still possessing this remarkable power. St. Paul's churchyard may be looked upon as one of the oldest parts of London, and the water from the wells around it is remarkably pure, and the drainage of the soil is such that there is very little of any salts of nitric acid in it. If the soil, says Dr. Smith, has such a power to decompose by oxydation, we want to know how it gets so much of its oxygen. We must, however, look to the air as the only source, and see how it can come from it. When water becomes deprived of oxygen, it very soon takes it up again,—as may be proved by experiment. This shows us that as fast as the oxygen is consumed by the organic matter, it receives a fresh portion, conveyed to it by the porous soil. Several experiments of the following character were given, to show the filtering power of the soil. A solution of peaty matter was made in ammonia; the solution was very dark, so that some color was perceived through a film of only the twentieth of an inch in thickness. This was filtered through sand, and came out perfectly clear and colorless. Organic matter dissolved in oil of vitriol was separated from it by a thickness of stratum of only four inches. A bottle of porter was by the same process deprived of nearly all its color. The material of which this filter is made is of little importance. One of the best, according to Dr. Smith, as far as clearing the water is concerned, being of steel filings,—oxyd of iron, oxyd of manganese, and powdered bricks all answering equally well. This shows that the separation of the organic matter is due to some peculiar attraction of the surfaces of the porous mass presented to the fluid. This paper was a continuation of Dr. Smith's Report published last year,—and he proposes continuing the inquiry.

On the Proportion of Phosphoric Acid in some Natural Waters; by Prof. Voelcker.

The object of this paper was to draw attention to a natural source from which many of our fields may be economically supplied with phosphoric acid. Prof. Fownes has shown that traces of phosphoric acid are met with in many rocks of igneous origin, but also in stratified rocks, particularly in limestone rocks, the presence of phosphoric acid has been indicated by several chemists. The author found the proportion of phosphoric acid in graptolite, from the neighborhood of Cirencester, amounting to 0·124 per cent., equal to 0·260 of bone-earth, and in Stonesfield slate from the same locality amounting to 0·117, equal to 0·244 per cent. of bone-earth. As water, charged with carbonic acid, is capable of dissolving bone-earth, this important fertilizing substance is found in many natural waters, percolating rocks which contain phosphoric acid. Such waters, therefore, may be applied with advantage for irrigation. The advantages derived from this too often neglected natural source, are strikingly exhibited in the irrigated meadows in the neighborhood of Cirencester; and it is the opinion of the author that one of the chief causes of the beneficial effects which follow the application of the water for irrigation in this locality, is to be found in the phosphate of lime it contains. In a tea-kettle incrustation formed in a short period by this water, the proportion of phosphoric acid was found to amount to 1·25 per cent., showing a considerable quantity of this acid present in the water. A very hard water from Edinburgh likewise proved to contain phosphoric acid, but its proportion was not so large as that in the Cirencester water, the quantity of phosphoric acid in a boiler incrustation formed by this Edinburgh water being only 0·427 per cent. Sea-water also contains phosphoric acid, but the proportion amounts to mere traces. A quantitative determination of phosphoric acid in the boiler deposit of a Canada steamer gave only 0·0306 per cent., and that in a boiler incrustation of a steamer plying between Dublin and Liverpool 0·0424 as the per-centage of phosphoric acid. In conclusion, the author recommended Svanberg's test, molybdate of ammonia, as a ready means for deducing the presence of phosphoric acids in natural waters.

The Phosphorescence of Potassium; by Mr. W. Petrie.

While speculating on the consequences of the dynamical theory of heat, I was led to the conclusion that cold potassium *ought* to be found *luminous;* and farther, that it ought to be only about a *tenth part* as *luminous* as *phosphorus.* On testing this experimentally, with the precautions for sensitive vision which the anticipated feebleness of the light indicated to be necessary, the result was, that on dividing a bit of potassium, (which was quite dry, being protected only by a coating of bees' wax,) the halves showed two *distinctly luminous sections;* the light being about *a tenth* of that from a similar surface of phosphorus, as far as the eye could make the comparison. The light diminished, naturally, as a protecting coating of oxyd was formed, but remained just perceptible to the most sensitive sight, as long as half an hour.

On the presence of Fluorine in Blood and Milk; by Dr. G. Wilson.

In 1846 I announced to the Royal Society of Edinburgh that after finding that fluor spar was soluble in water, and occurred in many natural waters, I thought it well to seek for it in milk and blood, and found distinct evidence of its presence in both. The proofs however were not so decisive as I could have wished. This summer, however, I have employed the fresh drawn blood of the ox. About 26 imperial pints or 3 gallons of blood were made use of. From the large scale on which the experiment was conducted, and the simplicity of the process followed, the evidence in favor of the presence of fluorine in the blood of the ox seems unexceptionable; and it cannot be doubted that the blood of other animals will be found to contain the same element. I presume it to be present in the state of fluoride of calcium, and that its amount is very small; but I have not attempted its quantitative determination. Milk was examined in a similar way, with nine imperial pints of rich milk from a country farm. The vapor which they evolved etched glass distinctly. The ashes of twelve pound of new skim-milk cheese made this spring treated in the same way occasioned deep etching of glass. The ashes of four imperial pints of whey treated in the same way have barely marked glass so as to show the faintest outlines when breathed upon. In all probability the fluorid of calcium is associated with the phosphate of lime, and when milk is coagulated separates along with the caseine. Dr. Wilson also stated that he had repeated the inquiry into the solubility of fluorid of calcium in water, reported to the Association at its Southampton meeting, and with the same result, viz., that 16 fluid ounces, or 7,000 gr. of water, at 60°, dissolve 0·26 gr. of fluor spar.

Another New Planet.—On the 13th of Sept., 1850, another new planet was discovered by Mr. J. R. Hind, of London. Its place, Sept. 13, $11^h\ 29^m\ 3^s$ Gr. m. t. was R. A. $23^h\ 44^m\ 45^s{\cdot}08$, and N. decl. $14^\circ\ 6^m\ 42^s{\cdot}9$. It is probably one of the Asteroidal group.

Supposed Staurotide of Norwich, Mass.—Notwithstanding the resemblance to Staurotide in these crystals, and the identity with that species in the prismatic angles, they are found by Mr. W. J. Craw, on chemical examination, to be a phosphate of manganese, iron and lithia. Mr. Craw has them under investigation, but has not yet completed his analyses. Several of the crystals appear to have a slight obliquity between the terminal and lateral planes.—J. D. D.

General Index.—We close this volume with a general Index to the first ten volumes of this series of the Journal, intending to continue the plan with every succeeding tenth volume, believing that the value of the Journal will be thus enhanced, as well as its convenience to our readers. Some articles now on hand, are consequently deferred to another volume.—*Eds.*

Errata.—The Errata of the ten volumes of this series are to be found on page viii of each volume, also in volume iii, p. 464; also for additional errata of vol i, see vols ii. and iii, p. viii; of vol. iii, see vol. iv, p. viii; of vol. v, see vol. vi, p. viii; of vol. vi, see vol. vii, p. viii; of vol. viii, see vol. ix, p. viii.

Other Errata not mentioned, are as follows:—

Vol. iv, p. 278, for Tautolite, read Tachylite,
p. 356, in note, for vol. i, read vol. ii.
Vol. v, p. 337, 8 l. from top, for $\dot{\mathrm{Ca}}\,\ddot{\mathrm{C}}$, read $\dot{\mathrm{Ca}}\,\dddot{\mathrm{S}}$.
Vol. vii, p. 114, 2 l. from top, for Marbury, read Marburg.
20 l. from top, for $4\bar{\mathrm{Al}}\,\dddot{\mathrm{Si}}$, read $5\bar{\mathrm{Al}}\,\dddot{\mathrm{Si}}$.
Vol. viii, p. 428, 7 l. from top, for Ephipphora, read Ephippiphora; and for Phil. Mag., read Ann. Mag. Nat. Hist.
Vol. ix, p. 399, last line, for Journal, read Proceedings.

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APPENDIX.

Report on Prof. Page's Electro-magnetic Engine; by Prof. WALTER R. JOHNSON.

[From the National Intelligencer.]

GENTLEMEN :—

In order to be able to answer the many inquiries which are daily put to me, orally or otherwise, respecting Dr. Page's recent applications of electro-magnetism to the propelling of machinery, I have made, with his consent, two series of experiments for the purpose of ascertaining the amount of power actually exercised at present by the machine recently exhibited at the Smithsonian Institution. My attention was primarily directed to ascertaining, 1st, the proportion between the weight resting on the periphery of the fly-wheel to produce friction, and the amount of resistance to motion which that friction produced. 2d, the true periphery of the fly-wheel. 3d, the amount of insistent weight or actual pressure caused by the friction brake. 4th, the number of revolutions of the engine made under every load with which the engine was charged.

September 17, 1850, I passed a measuring tape round the fly-wheel and found it 13 feet 3½ inches in circumference, say 13·29 feet.

2. I weighed the friction lever and found it 13 pounds 6½ ounces, or 13·406 pounds. I found its centre of gravity to be 2 feet 10¼ inches from the fulcrum, and the fulcrum 7¼ inches from the point of application of the lever, or rather of the plate of brass fixed beneath it. Hence the pressure exercised by the lever alone upon the fly-wheel is 62·78 pounds, which may practically be called 63 pounds.

I found the extreme point of application of the weights to the lever to be 6 feet 10 inches from the fulcrum. Hence the leverage with which the weights act on the wheel is 11·31 to 1. If the lever were without weight, or were rendered so in effect by counterpoising, a weight of 5·55 pounds would produce the same pressure when applied at the extremity, as the weight of lever itself now does; that is, 62·78 pounds. In all the experiments which I made, the weights were placed at the extremity of the friction lever.

3. To test the force of resistance created by the friction-brake, I caused a small cord, about ⅜ of an inch in diameter, to be placed beneath the fly-wheel and fastened to one of the spokes in such manner that the cord applied itself to the periphery. It was then carried over a pulley about on a level with the top of the wheel, and a short distance in front of the engine. The pulley was 4 or 5 inches in diameter, and its journal and cheeks were kept lubricated to diminish friction as much as possible.

The weights were applied to the wheel at four different points, so as to determine the differences in resistance encountered by the engine in the different parts of its revolution; that is, in the different positions of its crank. With 92·55 pounds at the extremity of the lever, including the effective weight of the lever itself, the insistent weight on the top of the wheel being 1046·74 pounds, it took, to keep the wheel barely moving at the first point tried, ... 159 lbs.
" 2d do. . . . . 166 "
" 3d do. . . . . 158 "
" 4th do. . . . . 158 "
Or an average of . . . . $160\frac{1}{4}$ "

Hence $160·25 \div 1046·74 = ·153$; or 15·3 per cent. is the ratio of the resistance to the weight which produced it. This includes the resistance at the axle as well as at the periphery of the wheel where the lever rests upon it, and also whatever resistance the connecting rod and moving bar of the engine encountered; for they were all connected and moved by the cord passing over the pulley.

4. Having detached the cord—the weights on the friction lever remaining as above—I applied the battery, having, as stated by Dr. Page, one-fourth more surface than had been used in his experiments at the Smithsonian Institution. The engine now made eighty-eight revolutions per minute. Hence

$$\frac{160·25 \times 13·29 \times 88}{33·000} = 5·7$$

horse power. The divisor here employed is that of Watt, and the power estimated includes the resistance of the engine caused by friction, &c.; but these are far less than in ordinary steam engines. It is proper to mention that the surface of the fly-wheel, when testing both the friction and the power of the engine, was kept fully lubricated, in order to give a steady and uniform resistance.

5. To ascertain the effect of giving a greater velocity and a diminished load to the engine, I took fourteen pounds from the weight on the friction brake, leaving 78·55 lbs. on the lever, and a direct pressure on the wheel of $78·55 \times 11·31 = 888·4$ pounds, on which, computing the friction at 15.3 per cent., we obtain 135·9 lbs. of resistance. Under this resistance the engine made ninety-six revolutions per minute, giving by a computation analogous to the preceding, 5·25 horse power. Hence it appears that the diminution of resistance did not give quite a corresponding increase of speed.

6. I next removed fourteen pounds more from the brake, leaving 64·58 pounds, and giving 730 pounds insistent weight. The engine then made one hundred and two revolutions per minute. This, by a like computation, proved the power to be that of 4·58 horses.* It hence

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* The formula used in computing the power of the engine is

$$\frac{(C+c)\frac{L}{l} \times \frac{w}{W} \times P \times t}{d} = \frac{W P r t}{d} = F =$$

the horse powers of the engine; where P is the periphery of the fly-wheel in feet, $t =$ the revolution per minute; $L =$ the longer arm of the lever, $l =$ the shorter appears that the diminution of useful effect was considerably more rapid than the increase of velocity.

The above experiments were made with the battery supplied with acid that had been used five times previous to this day's operations, as stated by the assistant in charge of the battery.

There were present during these trials, honorable Messrs. Davis, of Massachusetts, Dayton, of New Jersey, and Hale, of New Hampshire, of the United States Senate; Robert Beale, Esq., Sergeant-at-arms of the Senate; Erskine Hazard, Esq., of Philadelphia; S. D. Dakin, Esq., of New York, and George W. Riggs, Esq., of Washington.

September 18th, 1850.—In order to ascertain what effect would be produced by using fresher acid, and an addition of about one-twentieth to the battery service, having made a series of five trials similar to those of yesterday to ascertain the friction, and finding it under 64·55 pounds on the lever, to be fifteen per cent. very nearly, I allowed the engine to run under that weight, when the number of revolutions was one hundred and eleven. Two experiments had been made prior to this, and six were afterwards performed, making nine in all during this day, to test the power of the engine, all of which are contained in the following table:

Table of second day's work.

No. of trial.	$C+c=$ Weight on the lever.	$t=$ Revolutions of the engine per minute.	$W=(C+c)\frac{L}{l}$ Effective pressure of the brake.	$w=$ Effective resistance to motion.	$F=$ Horse power of the engine.	Velocity of the bar per second.
	Pounds.		Pounds.	Pounds.		Feet.
1	99·55	90	1,125·9	168·9	6·12	6·00
2	92·55	101	1,046·7	157·0	6·38	6·73
3	64·55	111	730·	109·5	4·89	7·40
4	78·55	110	888·4	133·2	5·90	7·33
5	92·55	108	1,046·7	157·0	6·82	7·20
6	99·55	102	1,125·9	168·9	6·93	6·80
7	109·30	85	1,236·2	185·7	6·35	5·66
8	112·30	76	1,270·1	190·5	5·83	5·06
9	117·30	96	1,326·7	199·0	7·69	6·40

The 9th experiment was made after the battery had been brought into very vigorous action by the use of a short circuit, not pertaining to

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arm of the lever, $C=$ the weight hung at the extremity of the lever, $c=$ weight equivalent in effect to the weight of lever when applied at its extremity, $W=(C+c)\frac{L}{l}=$ effective pressure of lever upon the wheel, $w=$ the weight appended to the cord in trying resistance, $r=\frac{w}{W}$ ratio of resistance to the insistent weight, $d=$ the dynamic unit ($=33000$), $F=$ the number of horse powers of the engine, including the friction within the machine itself.

the engine. Bringing together the *first day's work* it shows the following synopsis:

1	92·55	88	1,046·7	160·25	5·70	5·86
2	78·55	96	888·4	135·9	5·25	6·40
8	64·55	102	730·	111·7	4·58	6·80
The average of both days gives (horse power)............					6·03	

It appears that the 3d, 2d, and 1st experiments of the first day correspond respectively with the 3d, 4th, and 5th of the second day, in regard to the weights applied to the lever. In both cases the higher velocities gave the lower efficiencies of the engine. The change in the battery produced a useful effect, amounting to about seven per cent. at the highest velocity of the day; of twelve per cent. at the medium velocity, and of nineteen per cent. at the slowest rate of motion, which is about the fair working speed for each day. Eighty-eight revolutions appear to have been the best speed on the first day's trial, and 102 to 108 on the second day. The alteration in the state of the battery had increased the action of the engine nearly twenty per cent. The trials on the second day were witnessed by Hon. Mr. Wright, of California, Marshal Tukey, of Boston, Rev. Thomas Sewall, of Washington, Mr. Fillebrown, of the Navy Department, and Messrs. Willards, brothers, of Washington. Yours, respectfully,

WALTER R. JOHNSON.

WASHINGTON, September 19, 1850.

In addition to the above, we add an additional fact, stated to us in a letter from Prof. Page, dated, Patent Office, Oct. 14, 1850.—EDS.

"My engine has now reached ten horse power. The data is as follows: Engine, two feet stroke; fly wheel, 13·29 feet in circumference, 102 revolutions, with 1900 pounds pressure upon its periphery."